2024-2061

United States Court of Appeals
for the Federal Circuit

——————————————

DIVX, LLC,

Plaintiff-Appellee

v.

REALTEK SEMICONDUCTOR CORPORATION,

Defendant-Appellant

LG ELECTRONICS INC., LG ELECTRONICS USA, INC.,

Defendants

——————————————

Appeal from the United States District Court for the District of Delaware
Case No. 1:20-cv-01202, Judge Jennifer L. Hall
DivX, LLC v. LG Electronics, Inc., et al.

——————————————

APPELLANT'S PRINCIPAL OPENING BRIEF

——————————————

October 9, 2024

Theodore J. Angelis
K&L Gates LLP
925 Fourth Avenue, Suite 2900
Seattle, WA 98104-1158
Phone: +1.206.623.7580
Theodore.Angelis@klgates.com

*Counsel for Appellant Realtek
Semiconductor Corporation*

<u>CERTIFICATE OF INTEREST</u>

Counsel for Appellant Realtek Semiconductor Corporation certifies the following:

1.   The full name of every entity represented by us is:

Realtek Semiconductor Corporation

2.   The name of the real party in interest for the entity. Do not list the real parties if they are the same as the entities.

None/Not Applicable

3.   Provide the full names of all parent corporations for the entities and all publicly held companies that own 10% or more stock in the entities.

None/Not Applicable

4.   List all law firms, partners, and associates that (a) appeared for the entities in the originating court or agency or (b) are expected to appear in this court for the entities. Do not include those who have already entered an appearance in this court. Fed. Cir. R. 47.4(a)(4).

Jason A. Engel (K&L Gates LLP), Matthew B. Goeller (K&L Gates LLP), Robert J. Benson (Baker Botts LLP), and Christopher J. Higgins (Orrick, Herrington & Sutcliffe LLP).

5.   Provide the case titles and numbers of any case known to be pending in this court or any other court or agency that will directly affect or be directly affected by this court's decision in the pending appeal. Do not include the originating case number(s) for this case. Fed. Cir. R. 47.4(a)(5). See also Fed. Cir. R. 47.5(b).

Realtek Semiconductor Corporation v. ITC (Fed. Cir. No. 23-1095)

6.   Provide any information required under Fed. R. App. P. 26.1(b) (organizational victims in criminal cases) and 26.1(c) (bankruptcy case debtors and trustees). Fed. Cir. R. 47.4(a)(6).

None/Not Applicable

TABLE OF CONTENTS

Page

TABLE OF AUTHORITIES

Page(s)

ii

STATEMENT OF RELATED CASES

Realtek respectfully identifies the following related case:

- Federal Circuit Appeal No. 2023-1095.

Federal Circuit Appeal No. 2023-1095 arises from ITC Investigation No. 337-TA-1222, which initially involved essentially the same patents and infringement claims that were at issue in the district court proceedings below. The parties in the 1337 Investigation were:

(1) Samsung Electronics Co., Ltd., Samsung Electronics America, Inc., and Samsung Electronics HCMC CE Complex, Co. Ltd. (collectively, "Samsung"); (2) LG Electronics Inc. and LG Electronics U.S.A., Inc. (collectively, "LG"); and (3) TCL Corporation, TCL Technology Group Corporation, TCL Electronics Holdings Limited, TTE Technology, Inc., Shenzhen TCL New Technologies Co. Ltd., TCL King Electrical Appliances (Huizhou) Co. Ltd., TCL MOKA International Limited, and TCL Smart Device (Vietnam) Co., Ltd. (collectively, "TCL").

JURISDICTIONAL STATEMENT

On July 30, 2021, the District Court dismissed DivX's patent infringement claims against Realtek's LG co-defendants, pursuant to a settlement agreement. On June 4, 2024, the District Court dismissed DivX's patent infringement claims against Realtek without prejudice.

On July 5, 2024, Realtek timely appealed the District Court's dismissal order. This Court has jurisdiction to review the District Court's dismissal order pursuant to 28 U.S.C. § 1295(a)(1).

STATEMENT OF THE ISSUES

1.   Whether the District Court erred, when considering whether to dismiss the claims against Realtek with or without prejudice, by completely failing to consider and weigh one of the governing factors, in violation of Third Circuit precedent.

2.   Whether the District Court erred by failing to consider the facts Realtek presented in connection with two of the governing factors, as Third Circuit authority likewise requires.

3.   Whether the District Court erred, when deciding whether to dismiss the claims against Realtek with prejudice, by refusing to consider that DivX had offered to dismiss its claims with prejudice, subject to certain conditions, which other courts have found critically important when deciding to dismiss claims with prejudice.

INTRODUCTION

In this patent infringement case, DivX sued Realtek alleging that certain Realtek integrated circuits infringe DivX's patents. The Realtek integrated circuits (called "chips," for simplicity, in this brief) passed through a chain of distributors around the world and were ultimately included in LG's and TCL's smart televisions sold in the United States. DivX's targets in the underlying litigation were LG and TCL, but DivX knew it would have trouble obtaining discovery from Realtek. Thus, DivX brought claims against Realtek for an improper purpose: to obtain discovery

it otherwise could not readily obtain from Realtek because it is a Taiwanese company based in Hsinchu, Taiwan.

Realtek contended below that DivX's claims against it were baseless and not well grounded in fact or law. Realtek—concerned about the negative impact such groundless claims have on consumers—vigorously defended itself and filed, for example, two motions for judgment on the pleadings. Realtek also served a Rule 11 motion. While those motions were pending, DivX convinced the District Court to stay the case over Realtek's objection, on the promise that the co-pending ITC action DivX had brought against Realtek, MediaTek, LG, Samsung, and TCL would significantly simplify the District Court case. DivX thus forced Realtek to spend millions of dollars defending, before the ITC, meritless claims DivX did not actually intend to pursue against Realtek.

DivX's gamesmanship was confirmed in February 2021, when it offered to drop all claims against Realtek in exchange for discovery cooperation. After Realtek refused, DivX continued to demand extensive discovery from Realtek to use against its real targets—the television makers whose smart TVs include Realtek chips. Ultimately, in early July 2021 (after discovery was complete, and just days before trial before the ITC), DivX, as expected, dropped all claims against Realtek in the ITC Investigation.

In July 2021, when DivX broached the topic of dismissing its claims, it initially offered to do so only if Realtek would agree to forego seeking sanctions against DivX in the ITC. Realtek refused. DivX nonetheless dismissed its claims against Realtek.

Although DivX dismissed its claims against Realtek before the ITC in July 2021, it did not seek dismissal of the claims it had brought against Realtek in the District Court. In fact, DivX waited more than *two years* before moving to dismiss its District Court claims. And when it finally, belatedly, sought to dismiss the District Court claims, it sought dismissal ***without*** prejudice.

Realtek opposed DivX's request to dismiss its claims without prejudice. Realtek explained that—given the history of the case and DivX's conduct—dismissal without prejudice was not warranted under the four factors that govern the District Court's decision. Those four factors, as the District Court recognized, are:

> 1) any excessive and duplicative expense of a second litigation; 2) the effort and expense incurred by a defendant in preparing for trial; 3) the extent to which the pending litigation has progressed; and 4) the claimant's diligence in moving to dismiss.

Appx3.

The District Court ultimately granted DivX's motion to dismiss without prejudice. In doing so, the District Court committed two errors. First, it completely failed to consider Factor (4)—the claimant's diligence in moving to dismiss. The Third Circuit has long held that failure to consider and weigh each factor, within a

5

multi-factor test, requires reversal and remand. *See Anthuis v. Cold Indus. Operating Corp.*, 971 F.2d 999, 1010-13 (3d Cir. 1992). Under Third Circuit authority, this Court may not correct that error by independently examining the factor the District Court ignored. As the Third Circuit explained: "[T]he function of analyzing and balancing these considerations is not ours to undertake." *Id.* at 1012. Accordingly, Third Circuit authority provides that the Court should reverse the order dismissing DivX's claims without prejudice and remand to the District Court so that it can consider and weigh *all* of the required factors.

Second, the District Court failed to address the facts presented when considering Factors (2) and (3). Below, Realtek showed that those factors—which address the resources spent to prepare for trial and the extent to which the litigation has progressed—weighed significantly in favor of dismissal with prejudice. Indeed, Realtek cited a case involving nearly identical circumstances, in which a judge in another district concluded that when an ITC investigation proceeds to the eve of trial, the companion district court case (stayed in favor of the ITC investigation) has progressed too far to allow dismissal without prejudice. *See Pathway Innovations and Techs., Inc. v. IPEVO Inc.,* No. 3:17-cv-00312-CAB-BLM (S.D. Cal. Feb. 13, 2020), Dkt. No. 40 (*dismissed with prejudice*) (concluding that claims brought in the district court and in the ITC, even though stayed before the district court, had been

litigated to the eve of trial in the ITC and therefore the resources spent, and record created, were too great to allow dismissal without prejudice); *see also* Appx373-374.

Rather than address these facts, and consider how DivX's claims against Realtek had developed before the ITC, the District Court considered the ITC litigation only in connection with Factor (1). Appx3. That failure likewise constitutes a violation of the Third Circuit's requirement that the district courts consider *each* factor of the four-factor test be considered and weigh them against each other before making a final decision.

Finally, the District Court also erred in failing to consider that DivX had offered to dismiss its claims with prejudice, subject to certain conditions. *See* Appx373, Appx505-512. District courts in the Third Circuit have relied on similar offers as justification for dismissal with prejudice. *See, e.g.*, *Wi-LAN Inc. v. Sharp Electronics Corp.*, No. 15-379-LPS, at *1-*2 (D. Del. Feb. 15, 2018); *Wrinkl, Inc. v. Meta Platforms*, No. 20-1345-RGA, 2023 WL 6929359, at *2 (D. Del. Oct. 19, 2023) (holding that the plaintiff's offer to dismiss some claims with prejudice and others without prejudice justified dismissing all claims with prejudice). Each of these errors independently justifies reversal and remand.

STATEMENT OF THE CASE

DivX filed this action on September 9, 2020. Appx91-131. The following day, DivX filed a complaint with the ITC alleging infringement of the same patents.

Appx177-248. Realtek quickly ascertained that DivX's claims were baseless and

that DivX had brought the claims for an improper purpose. Appx300. On November

17, 2020, Realtek sent a detailed, six-page letter to counsel for DivX outlining many

of the reasons DivX's allegations against Realtek are baseless and frivolous. DivX's

counsel responded on November 24, 2020. *Id.*; *see also* Appx389-400.

In February 2021, just prior to the *Markman* hearing in the ITC action, DivX

had offered to dismiss all claims against Realtek so long as Realtek cooperated in

providing discovery that DivX could use in pursuing claims against DivX's

customers.[1] Appx380. In particular, DivX contacted Realtek and said that it would

dismiss all claims against Realtek, with no payment from Realtek, if Realtek would

agree to (1) provide additional, expedited discovery, to be used against the TV

brands who purchased Realtek's chips and (2) to give up its claim for recovery of

fees and costs. *Id.* Realtek said it would agree to dismissal only if dismissal would

preserve Realtek's right to bring a sanctions motion, in the ITC, against DivX. *Id.*

---

[1] Realtek is reluctant to reveal settlement discussions, but when such discussions are
relevant to an issue other than liability, they are admissible. *See* Fed. R. Evid.
408(b); *see also, e.g.*, *Giganti v. Gen-X Strategies, Inc.*, 222 F.R.D. 299, 313 (E.D.
Va. 2004) ("While the Rule itself does not expressly indicate that a motion for
sanctions qualifies as 'another purpose' such that the rule of exclusion does not apply
here, courts in this and other circuits have considered settlement documents when
reviewing a motion for sanctions.") (collecting cases).

Realtek even offered to allow both sides to bring sanctions motions, if DivX believed

it could justify such a motion (as it had suggested). *Id.* DivX refused. *Id.*

On February 23, 2021, DivX informed Realtek that "DivX intends on filing a

motion to terminate the Investigation-in-part" with respect to all claims in the '297

patent and the '141 patent. Appx378, Appx408. Realtek responded by saying:

"Realtek does not oppose termination of all asserted claims from the '141 and '297

patents against Realtek," but Realtek noted that its non-opposition "is without

prejudice to requesting relief under Commission Rules 210.4 and 210.25[,]" which

are the ITC's rules analogous to Rule 11. Appx407.

On March 2, 2021, Realtek filed its answer in the District Court case below

and a Rule 12(c) motion for judgment on the pleadings, based on the fact that the

claims of the four patents-in-suit are directed to patent ineligible subject matter under

35 U.S.C. §101. Appx132-164.

In the meantime, fact discovery was nearing completion in the ITC

investigation. Fact discovery was originally scheduled to close on March 5, 2021,

but it was extended to March 26, 2021. Appx301, Appx306-324. On March 9, 2021,

DivX moved to stay this case. Appx165, Appx175.

On March 7, Realtek served its Rule 11 motion. Appx371. That motion raised

violations of Rule 11, including that DivX's motion was brought for the improper

purpose of avoiding the need to conduct third-party discovery on Realtek. Appx421,

Appx425-426, Appx437-438). Realtek also showed that DivX's claims were not well grounded in fact or law. Appx420-422, Appx425-436.

Plaintiff filed its motion to stay on March 9, 2021, about two weeks prior to the close of fact discovery in the ITC action. Appx165-Appx299. The Court granted that motion on June 3, 2021, about a month before trial was to begin in the ITC action. Appx330. In granting the motion, Judge Hall reasoned: "The ITC case is set for trial next month. The Court finds that this action and the pending ITC case have sufficient overlapping factual and legal issues such that there is a potential for significant simplification of this litigation . . . ." *Id.* at 1.

DivX continued to pursue its claims in the ITC against Realtek until the eve of trial, forcing Realtek to incur millions of dollars in attorneys' fees and costs. Appx380. In early July, just before trial was scheduled to begin on July 7, 2021, DivX once again offered to dismiss all claims against Realtek, but only if Realtek would agree not to use the dismissal as a basis for seeking sanctions. *Id.* Realtek again refused because DivX's conduct confirmed that DivX had acted improperly in the ITC case. *Id.* DivX nonetheless dismissed all claims against Realtek immediately before trial began on July 7, 2021. *Id.* (mistakenly listing hearing start date as July 6, 2021). DivX's actions confirmed that its plan was to use unsupported claims to obtain discovery from Realtek and then to dismiss all claims against Realtek on the eve of trial.

DivX settled with LG in late June or early July 2021, at about the same time

DivX dismissed its claims in the ITC against Realtek. Appx371. DivX thereafter

went to trial against TCL and fully litigated its claims related to Realtek's accused

chips. Although DivX had dismissed its claims against Realtek just before trial, it

pursued, through trial, its claims that Realtek's chips, as used in TCL's televisions

and coupled with TCL's technology, caused TCL's televisions to infringe at least

one of DivX's patents. (The claims against Realtek's chips constituted roughly ¼

of the trial testimony because TCL also used video processors made by another

supplier, MediaTek, and because DivX's primary claims were directed to video

streaming patents unrelated to any technology Realtek offers. *Id.)* At trial, DivX

presented false and misleading testimony regarding Realtek's chips, which is one

subject of Realtek's motion for sanctions before the ITC. Appx456-495.

Although DivX dismissed its claims against Realtek in July 2021, and it

settled its claims against LG in July 2021, it took no action with respect to this case

until 14 months later, in September 2022. Appx371, Appx496-499. Notably, DivX

took other actions before the District Court to benefit itself. For example, on July

29, 2021, DivX dismissed its claims against LG with prejudice. Appx333-335.

DivX did not, however, take any steps to dismiss or pursue its claims against Realtek.

Appx371. DivX later settled with TCL, and it again promptly sought dismissal of

the claims against TCL pending before the District Court. *DivX, LLC v. TCL Corp.,*

No. 1:20-cv-01203 (D. Del. Apr. 26, 2022), Dkt. No. 15. Again, DivX did not, however, take any steps to dismiss or pursue its claims against Realtek. Appx372.

It was not until about 14 months after DivX's dismissal of claims against Realtek in the ITC, on September 13, 2022, that DivX finally contacted Realtek and suggested the parties meet and confer regarding next steps before the District Court. Appx371, Appx496-499. The parties spoke by phone, and later, on September 30, 2022, Realtek responded that dismissal with prejudice was the only appropriate course of action given the multi-year pendency of the case and Realtek's "grave concerns about the viability of DivX's claims." Appx372, Appx496-499. DivX replied on September 30, 2022, and indicated that it intended to use the extensive record developed before the ITC in the District Court, as the District Court intended when it granted a stay. Appx372, Appx500-504. Specifically, DivX asked Realtek to confirm that the parties would both be using "the Commission record in the district court proceedings and that the parties will also agree to cross-use of any discovery responses, document productions, reports, transcripts, etc." Appx372; *see also* 28 U.S.C. § 1659 ("[T]he record of proceeding before the United States International Trade Commission shall be transmitted to the district court and shall be admissible in the civil action, subject to such protective order as the district court determines necessary, to the extent permitted under the Federal Rules of Evidence and the Federal Rules of Civil Procedure.").

The parties subsequently submitted a Status Report on October 12, 2022. Appx336-337. The case then sat dormant for about a year, during which time DivX took no steps to contact the Court or seek dismissal. On September 8, 2023, the Court set a status conference, and only then did DivX take any steps toward dismissal. At the Court's instruction, the parties again met and conferred to determine if they could reach agreement regarding dismissal. Appx372-373. During those discussions, Realtek insisted upon dismissal *with prejudice* for the reasons that had been discussed more than a year earlier. *Id.*

On September 25, 2023, the parties submitted a letter to the Court explaining their positions. Appx338-339. DivX indicated that it was evaluating whether to file an opposed motion to dismiss without prejudice, whether to litigate the case, or whether to agree with Realtek to dismiss with prejudice. *Id.* DivX subsequently offered to dismiss its case against Realtek with prejudice if Realtek would agree that such dismissal would not impact its ability to sue Realtek's customers. Appx373, Appx505-512. Realtek declined that request, and it responded that only a dismissal with prejudice would be appropriate given the case history. DivX filed its motion to dismiss without prejudice on October 30, 2023. Appx373.

The District Court issued a Memorandum Order on June 4, 2024. Appx1-3. The District Court began by reciting the procedural background of the case but omitted some of the procedural history recounted above, such as the Rule 11 motion

that Realtek served on DivX prior to the stay. *See supra* pp. 12-13. The District

Court next recited applicable law. The District Court recognized that Third Circuit

law controlled and, pursuant to governing authority:

> In determining whether legal prejudice will result from dismissal of a claim without prejudice, courts in this circuit consider (1) any excessive and duplicative expense of a second litigation; (2) the effort and expense incurred by a defendant in preparing for trial; (3) the extent to which the pending litigation has progressed; and (4) the claimant's diligence in moving to dismiss.

Appx3.

The Court's discussion and analysis of these factors was exceedingly short.

The Court said:

> When the Court stayed this case in 2021, it was in its infancy. It still is. There is no scheduling order and there has been no discovery.[1] Having considered the factors, the Court will exercise its discretion to grant DivX's request to dismiss the case without prejudice.

Id. Within its discussion, the District Court included a footnote that elaborated on

Factor (1), which the Court slightly rephrased as an analysis of whether dismissal

without prejudice would "result in a significant or duplicative additional expense

were DivX *to file again*." *Id.* (emphasis added). The Court reasoned that a second

action would not create significant or duplicative additional expense because the

extensive ITC record would be available in a subsequent case. The Court also noted

that Realtek had spent millions of dollars in fees in developing the robust record in

the ITC, but rather than address that fact in connection with the governing factors,

the Court noted only that Realtek could pursue (and, indeed was pursuing) sanctions against DivX for misconduct before the ITC.

With respect to Factors (2) and (3), the District Court did not address the fact that fact and expert discovery, a *Markman* hearing and order, and pre-trial proceedings had occurred in the ITC. Nor did the District Court address the fact that it had stayed the case explicitly to allow discovery and pre-trial proceedings to occur in the ITC, which would simplify (i.e., in lieu of proceeding in) the District Cout case. Appx1-3. The District Court likewise did not analyze the impact on Factors (2) and (3) of DivX's stated intention to rely on the ITC record in the District Court proceeding. *Id.* The District Court did not consider the authority Realtek had cited, in which another district court concluded that a case in an identical posture had progressed too far to allow dismissal without prejudice. *Id.*

The District Court did not analyze, address, or weigh Factor (4) at all. *Id.* The only mention of Factor (4) was when the Court articulated the standard that governed its exercise of discretion. *Id.*

SUMMARY OF THE ARGUMENT

The District Court erred by failing to consider Factor (4). In the Third Circuit, the failure to analyze and weigh any factor of a multi-factor test is reversible error. *Anthuis*, 971 F.2d at 1012. Here, the District Court merely listed, and did not analyze, Factor (4). The District Court's failure to analyze Factor (4) was especially

inappropriate for two reasons. First, Realtek relied heavily on Factor (4) when urging dismissal *with* prejudice. Realtek showed—based on the undisputed facts—that DivX had not diligently pursued dismissal. Second, Realtek cited cases in which other judges in the Third Circuit, when considering a similar factual record, found Factor (4) especially salient when ordering dismissal *with* prejudice. In the Third Circuit, the Court of Appeals may not weigh a factor that a district court did not consider. *Id.* (emphasis added). Accordingly, the District Court's failure to address Factor (4) requires reversal and remand so that the Court can address that factor.

The District Court erred in failing to examine whether Factors (2) and (3) weigh in favor of dismissal given the extensive record the parties developed, at great expense, for use in both the ITC and in the District Court. The District Court did briefly discuss the millions of dollars in fees that Realtek incurred in connection with fact discovery, expert discovery, claim construction, pre-trial, and trial before the ITC. Appx3. But the District Court only considered those facts in the context of Factor (1). Appx354, Appx363-365. Under Third Circuit authority, the District Court's failure to provide any analysis of those facts in connection with Factors (2) and (3), and its failure to perform any analysis of Factors (2) or (3) at all, justifies reversal and remand. *Anthuis*, 971 F.2d at 1012-13. The District Court's failure to consider these facts in connection with Factors (2) and (3) is unjustifiable because—when discussing Factors (2) and (3)—Realtek relied heavily on the parties'

16

agreement that the extensive record developed before the ITC would be used in the District Court case. As Realtek explained, DivX itself stated that the parties would use "the Commission record in the district court proceedings and that the parties will also agree to cross-use of any discovery responses, document productions, reports, transcripts, etc." Appx358 The District Court, when staying the case, likewise confirmed that the ITC record would be used to simplify issues in the District Court. *See* Appx330. Despite the fact that the record developed before the ITC (at a multi-million-dollar expense) was simultaneously developed for use in the case below, the District Court never considered how that fact impacted Factors (2) and (3). Under Third Circuit authority, the District Court's failure to explain its analysis of Factors (2) and (3), like its failure to consider Factor (4), justifies reversal and remand. *Anthuis*, 971 F.2d at 1012-13.

The District Court erred in refusing to consider that DivX previously offered to dismiss its claims with prejudice, subject to certain conditions. District courts in the Third Circuit have frequently relied on offers to dismiss claims with prejudice—whether or not subject to conditions—as justification for dismissal with prejudice. *See Wi-LAN Inc.*, No. 15-379-LPS, at *1-*2; *Wrinkl, Inc.*, 2023 WL 6929359, at *2. In opposing DivX's motion to dismiss without prejudice, Realtek relied on DivX's offer to dismiss with prejudice, with certain conditions, as a basis for dismissing its claims with prejudice. Appx354-355, Appx359. The District Court did not,

17

however, address DivX's offer or consider whether that offer supports dismissal with prejudice. It is well established, and this Court has held, that failure to address a legal argument that a party raised is an abuse of discretion. Accordingly, this error, like the other two errors addressed above, justifies reversal and remand.

STANDARD OF REVIEW

The District Court's decision to grant dismissal without prejudice is a procedural issue governed by Third Circuit law. *Garber v. Chicago Mercantile Exch.*, 570 F.3d 1361, 1363-64 (Fed. Cir. 2009). In the Third Circuit, a decision to grant or deny a request for voluntary dismissal without prejudice "is a matter of judicial discretion." *Ockert v. Union Barge Line Corp.*, 190 F.2d 303, 304 (3d Cir. 1951). In exercising that discretion, district courts in the Third Circuit weigh four factors:

> 1) any excessive and duplicative expense of a second litigation; 2) the effort and expense incurred by a defendant in preparing for trial; 3) the extent to which the pending litigation has progressed; and 4) the claimant's diligence in moving to dismiss.

Mirtech, Inc. v. AgroFresh, Inc., No. 20-1170-RGA, 2023 WL 4457006, at *2 (D. Del. July 11, 2023). When an exercise of discretion depends upon application of multiple factors, the Third Circuit holds that "the mere listing of factors without further explanation and without *balancing one factor against another* is insufficient for meaningful appellate review." *Anthuis*, 971 F.2d at 1012 (emphasis added). The Court of Appeals therefore "require[s][] that, in each instance in which the district

18

court exercise its . . . discretion, it must articulate its considerations, its analysis, its

reasons and its conclusions touching on each of the [four] factors delineated . . . ."

Id. This requirement extends to every district court exercise of discretion that

depends upon weighing of multiple factors. *Id.* at 1012 n.13. When a district court's

analysis is "silent with respect to" one or more of the factors, the Court of Appeals

must refrain from "subsitut[ing] [its] judgment for that of the district court" and

therefore must reverse and remand to the district court. *Id.* at 1012.

<div align="center">

ARGUMENT

</div>

**I.   The District Court's Failure to Consider Factor (4) Requires
Reversal and Remand.**

The District Court erred in failing to analyze and weigh each factor of the

governing four-factor test. In the Third Circuit, the failure to consider a factor, in a

multi-factor test, is reversible error. *Anthuis*, 971 F.2d at 1012. Here, the District

Court merely listed, and did not analyze, Factor (4): "the claimant's diligence in

moving to dismiss." Appx3. Indeed, the District Court's only mention of this factor

is when it quoted the governing four-factor test. *Id.* Under *Anthuis*, the District

Court erred in failing to analyze Factor (4) and failing to balance it against the other

factors. 971 F.2d at 1012 & n.13.

The District Court's failure to analyze Factor (4) is particularly unjustified for

two reasons. First, Realtek relied heavily on that factor when urging dismissal with

<div align="center">

19

</div>

prejudice and showed a lack of diligence based on indisputable facts. Second, Realtek cited authority, in cases involving similar facts, in which other judges in the Third Circuit found Factor (4) especially salient when ordering dismissal *with* prejudice.

Realtek relied heavily on DivX's dilatory conduct as a basis for advocating dismissal with prejudice. *See, e.g.*, Appx352-354, Appx357-359, Appx365-367. Realtek pointed out that DivX withdrew its claims against Realtek in the ITC in July 2021 but waited more than two years to seek dismissal of the District Court case below. Appx353. Indeed, it waited more than 14 months until it even contacted Realtek to suggest a discussion about the claims in this case. Appx358, Appx371, Appx496-499.

During that time, as Realtek recounted in its opposition, DivX took other actions in the District Court to benefit itself but completely neglected its obligation to timely seek dismissal of claims against Realtek. Appx358, Appx371-372. For example, DivX dismissed its claims against co-defendant LG (whose TVs were the allegedly infringing instrumentality) in July 2021. Appx358, Appx371. In April 2022, it likewise dismissed all claims against TCL in a co-pending case. Appx358, Appx372. But it consistently failed to exercise any diligence with respect to the claims against Realtek. For example, DivX waited 5 months after the dismissal of its claims against TCL (from April 2022 to September 13, 2022), and 14 months

from its dismissal of claims against LG, to even contact Realtek to discuss how the case should proceed. Appx358, Appx371-372. It then waited *another* year, until a September 8, 2023, to let the District Court know that it intended to seek dismissal. Appx358-359, Appx372-373. It did not actually file its motion to dismiss until October 30, 2023. Appx359, Appx373. Realtek relied heavily on these facts when opposing dismissal *without* prejudice. Appx352-353, Appx 365-367.

Realtek also cited cases in which Factor (4) was especially salient. For example, in its opposition, Realtek relied on the district court's analysis in *Mirtech*, 2023 WL 4457006, at *3. Appx365-366. There, the district court judge ordered dismissal *with* prejudice in part because the plaintiff there had taken a "wait-and-see approach" to dismissal. Appx366. The *Mirtech* plaintiff had waited to dismiss until it knew how the record would develop. As Realtek explained, DivX took the same, impermissible "wait and see" approach against Realtek. It bided its time, awaiting development of a detailed factual and expert record during pre-trial and trial proceedings, all in an effort to exert maximum pressure on companies that use Realtek's chips. DivX kept Realtek on the hook until it was sure it no longer needed discovery from Realtek to use against those companies. Thereafter, DivX compounded its misconduct by ignoring the claims against Realtek for another year. *Mirtech* demonstrates that the "wait and see" posture that DivX employed here justifies dismissal with prejudice.

Given Realtek's emphasis on Factor (4), and cases applying Factor (4), it is inexplicable that the District Court completely failed to discuss, evaluate, and weigh that factor. Here, as in *Anthuis*, the District Court merely listed Factor (4) "without further explanation and without balancing [that] factor against another[.]" 971 F.2d at 1012.[2] The District Court "utterly failed to recognize, analyze, explain or enunciate conclusions concerning the . . . factor[] which it was required to consider." *Id.* The District Court could, and should, have considered Factor (4) and weighed it against the other factors, as Judge Andrews did in *Mirtech*. The failure to do so is reversible error, and this Court "must, therefore, return this aspect of the proceeding to the district court." *Id.* at 1013. Realtek therefore respectfully asks the Court to reverse the District Court's ruling and remand with instructions to consider, apply, and weigh Factor (4).

II.   The District Court Abused Its Discretion in Failing to Consider Whether the Facts Presented Demonstrate that Factors (2) and (3) Weigh in Favor of Dismissal With Prejudice.

The District Court further erred in failing to examine whether the facts Realtek provided caused Factors (2) and (3) to weigh in favor of dismissal with prejudice. The District Court did briefly discuss the millions of dollars in fees that Realtek incurred in connection with fact discovery, expert discovery, claim construction,

---

[2] The District Court did say that it had "considered the factors[.]" Appx3. That is not sufficient and is no different than a "mere listing of factors[.]" *Anthuis*, 971 F.2d at 1012. It does not provide the analysis and balancing the Third Circuit requires.

pre-trial, and trial before the ITC. Appx3. But the District Court only considered those facts in the context of Factor (1). Appx354, Appx363-365. Under Third Circuit authority, the District Court's failure to provide any analysis of those facts in connection with Factors (2) and (3), and any analysis of Factors (2) or (3) at all, justifies reversal and remand. *Anthuis*, 971 F.2d at 1012-13. *See generally supra* pp. 19-20.

Below, Realtek argued that because DivX had extensively litigated its claims in the ITC, up to the eve of trial, Factors (2) and (3) weigh in favor of dismissal with prejudice. Appx363-365. Indeed, Realtek showed that, in nearly identical circumstances, a judge in another district ordered dismissal with prejudice because of the effort and expense incurred and because of the extent to which the case had progressed. *See Pathway Innovations,* No. 3:17-cv-00312-CAB-BLM (concluding that a district court case stayed at its outset had progressed too far for dismissal without prejudice given the extensive litigation that occurred before the ITC); *see also* Appx373-374.

Rather than address the millions of dollars Realtek was forced to spend preparing for trial—which Factor (2) requires—or the fact that the ITC proceeding proceeded to the eve of trial—which Factor (3) requires—the District Court considered only Factor (1). Appx3. Indeed, both the text of the District Court's order and its discussion in footnote 1 refer only to Factor (1). *Id.*

23

There should be no doubt that the District Court's analysis addresses only Factor (1). In its order, the District Court explained: "For this reason, [i.e. because the Court had not entered a scheduling order and no discovery had occurred when it entered a stay,] I find that a dismissal without prejudice would not result in a *significant* or *duplicative* additional expense were DivX *to file again*." *Id.* (emphasis added). The District Court's language plainly indicates that it was addressing Factor (1): "any *excessive* and *duplicative* expense of a *second litigation*." *Mirtech*, 2023 WL 4457006, at *2 (emphasis added). The District Court's focus was on duplication that would be required if DivX were to file a second action, which is the focus of Factor (1). As the District Court said, it examined whether the record developed before the ITC would be "available in *any subsequent case*," which relates to Factor (1)'s concern for "excessive and duplicative expense of a *second litigation*." *Id.* (emphasis added).

Factors (2) and (3), in contrast, instruct courts to consider—without regard to any subsequent litigation—the extent to which the case as a whole progressed before the request for dismissal. The District Court did note that Realtek has "point[ed] out that it 'spent millions of dollar[s] and fees and costs' in the ITC case," but it did *not* analyze that fact in connection with Factor (2) or Factor (3). Appx3. Instead, it considered *only* whether Realtek had the right to seek sanctions in the ITC for DivX's misconduct. Whether Realtek could, and did, seek sanctions before the ITC

24

is irrelevant to Factor (2)—"the effort and expense incurred by the defendant in preparing for trial"—and Factor (3)—"the extent to which the pending litigation has progressed."

Had the District Court considered the facts presented in the context of Factor (2) and Factor (3), it would have concluded that those factors weigh in favor of dismissal with prejudice because the record developed before the ITC was for use in both the ITC and in the District Court. As discussed in detail in the Statement of the Case, when DivX belatedly contacted Realtek to discuss next steps in Delaware District Court litigation, more than 14 months after withdrawing its complaint before the ITC, DivX confirmed that it viewed the extensive ITC record as a part of the District Court record. *See supra* p. 18; Appx372, Appx500-504. Specifically, DivX noted that the parties would use "the Commission record in the district court proceedings and that the parties will also agree to cross-use of any discovery responses, document productions, reports, transcripts, etc." Appx372, Appx500-504; *see also* 28 U.S.C. § 1659 ("[T]he record of proceeding before the United States International Trade Commission shall be transmitted to the district court and shall be admissible in the civil action, subject to such protective order as the district court determines necessary, to the extent permitted under the Federal Rules of Evidence and the Federal Rules of Civil Procedure."). The District Court, itself, had confirmed that the ITC record would be used in the District Court. *See* Appx330 ("The ITC

case is set for trial next month. The Court finds that this action and the pending ITC

case have sufficient overlapping factual and legal issues such that there is a potential

for significant simplification of this litigation . . . .").

Despite the fact that the record developed before the ITC (at a multi-million-

dollar expense) was simultaneously developed for use in the case below, the District

Court never considered how that fact impacted Factors (2) and (3).[3] That, too, is

error that requires reversal and remand.

The District Court's failure to consider that the record developed before the

ITC was simultaneously developed for the case below is especially problematic

because other courts have found that fact especially important when deciding

whether to dismiss with prejudice. As Realtek showed, another district court—faced

with a case in essentially the same posture—refused the plaintiff's request to dismiss

without prejudice due to the extensive litigation that had occurred before the ITC.

See Pathway Innovations, No. 3:17-cv-00312-CAB-BLM; *see also* Appx373-374.

Under Third Circuit authority, the District Court's failure to explain its

analysis of Factors (2) and (3), like its failure to consider Factor (4), justifies reversal

and remand. *Anthuis*, 971 F.2d at 1012-13.

III. The District Court Abused Its Discretion in Failing to Consider DivX's Offer to Dismiss with Prejudice.

---

[3] In its analysis, the District Court likewise failed to address the fact that Realtek had filed two motions for judgment on the pleadings and also had served a Rule 11 motion. Appx1-3.

The District Court also erred in refusing to consider that DivX previously offered to dismiss its claims with prejudice, subject to certain conditions. *See* Appx373, Appx505-512. District courts in the Third Circuit have relied on similar offers to dismiss with prejudice—whether or not subject to conditions—as justification for dismissal with prejudice. *See Wi-LAN Inc.*, No. 15-379-LPS, at *1-*2; *Wrinkl, Inc.*, 2023 WL 6929359, at *2 (holding that the plaintiff's offer to dismiss some claims with prejudice and others without prejudice justified dismissing all claims with prejudice). In opposing DivX's motion to dismiss without prejudice, Realtek relied on DivX's offer to dismiss with prejudice, with certain conditions, as a basis for dismissing its claims with prejudice. Appx354-355, Appx359. The District Court did not, however, address DivX's offer or consider whether that offer supports dismissal with prejudice.

Federal Circuit authority is clear that a court must address all arguments raised by the parties. *See Saarstahl AG v. United States*, 78 F.3d 1539, 1544 (Fed. Cir. 1996) (reversing and remanding case, "because the court did not address all of the parties' arguments[.]"). Accordingly, this error, like each the errors addressed above, justifies reversal and remand.

CONCLUSION

For the foregoing reasons, Realtek respectfully asks this Court to reverse the District Court's order dismissing the claims against Realtek without prejudice and remand so that the District Court can analyze each of the governing factors and weigh them against each other, as Third Circuit precedent requires.

Dated: October 9, 2024

/s/ *Theodore J. Angelis*
Theodore J. Angelis
K&L Gates LLP
925 Fourth Avenue, Suite 2900
Seattle, WA 98104-1158
Phone: +1.206.623.7580
Theodore.Angelis@klgates.com

Counsel for Appellant Realtek
Semiconductor Corporation

CERTIFICATE OF COMPLIANCE

Pursuant to Federal Circuit Rule 32(b)(3) and Federal Rule of Appellate Procedure 32(g)(1), I hereby certify that the foregoing brief complies with the typevolume limitations in Federal Circuit Rule 32(b)(1) and Federal Rule of Appellate Procedure 32(a)(7)(B), because it contains 6,497 words, excluding the exempted parts under Federal Rule of Appellate Procedure 32(f) and Federal Circuit Rule 32(b)(2).

I further certify that this brief complies with the typeface requirements of Federal Rule of Appellate Procedure 32(a)(5)-(6) because this brief was prepared using 14-point Times New Roman font.

/s/ Theodore J. Angelis
Theodore J. Angelis

CERTIFICATE OF SERVICE

I hereby certify that on October 9, 2024, I electronically filed the foregoing Brief of Appellants with the United States Court of Appeals for the Federal Circuit through the Court's CM/ECF system. All parties are represented by registered CM/ECF users and will be served by the CM/ECF system.

/s/ Theodore J. Angelis
Theodore J. Angelis

ADDENDUM

ADDENDUM

TABLE OF CONTENTS

Dkt. No.	Document Description	Date	Appx. Pages
Dkt. 78	Memorandum Order	6/4/24	Appx1-3
Dkt. 1-1	US Patent No. 8,832,297	9/9/20	Appx4-19
Dkt. 1-2	US Patent No. 10,212,486	9/9/20	Appx20-45
Dkt. 1-3	US Patent No. 10,412,141	9/9/20	Appx46-64
Dkt. 1-4	US Patent No. 10,484,749	9/9/20	Appx65-90

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

DIVX, LLC,	)
	)
Plaintiff,	) Civ. Action No. 20-1202-JLH
	)
v.	)
	)
REALTEK SEMICONDUCTOR CORP.,	)
	)
Defendant.	)
	)

MEMORANDUM ORDER

This is a patent infringement case. Pending before the Court is Plaintiff DivX, LLC's

("DivX's") Motion to Dismiss Without Prejudice. (D.I. 65.) Defendant Realtek Semiconductor

Corp. ("Realtek") does not oppose dismissal, but it wants dismissal with prejudice. DivX's motion

is GRANTED, and the case is DISMISSED without prejudice.

I.   BACKGROUND

On September 9, 2020, DivX filed a complaint for patent infringement against LG

Electronics, Inc., LG Electronics U.S.A., Inc. (collectively, "LG"), and Realtek. The next day,

Plaintiff filed a complaint with the International Trade Commission involving the same patents

against LG, Realtek, some TCL entities (RealTek's customer), and others.   In November 2020,

shortly after the ITC instituted an investigation, LG filed an unopposed motion to stay this case as

to LG, which the Court granted. (D.I. 13, 15.) Realtek did not move to stay at that time.

On March 2, 2021, Realtek answered (D.I. 25) and filed a motion for judgment on the

pleadings (D.I. 26). On March 9, 2021, DivX moved to stay pending a final determination by the

ITC. (D.I. 30.) On March 23, 2021, DivX filed an Amended Complaint. (D.I. 32.) On April 6,

2021, Realtek answered the amended complaint (D.I. 42) and filed another motion for judgment

Appx1

on the pleadings (D.I. 43). On June 3, 2021, the Court stayed the case. (D.I. 55.) On July 29,

2021, DivX and LG stipulated to dismissal. (D.I. 57.)

DivX terminated Realtek from the ITC investigation prior to the hearing, leaving TCL,

Realtek's customer, as the sole respondent. After the hearing, DivX and TCL settled and jointly

moved to terminate the ITC investigation, which the ALJ granted on April 22, 2022.

In October 2022, DivX and Realtek filed a status report advising this Court that the ITC

case was over and that "[DivX] has informed Realtek that [DivX] will move to dismiss its claims

against Realtek without prejudice upon the reopening of this case." (D.I. 58 at 2.) From there,

nothing happened until the Court ordered a status conference in September 2023. (D.I. 59.) At

that time, the parties agreed that the case should be dismissed but disputed whether it should be

with or without prejudice. (D.I. 61, 63.) On October 30, 2023, Plaintiff filed the pending motion

to dismiss without prejudice. (D.I. 65.) Realtek does not oppose dismissal, but it wants dismissal

with prejudice.

On January 12, 2024, the case was reassigned to me.

II.   LEGAL STANDARD

Rule 41(a)(2) of the Federal Rules of Civil Procedure provides as follows:

> Except as provided in Rule 41(a)(1), an action may be dismissed at
> the plaintiff's request only by court order, on terms that the court
> considers proper. . . . Unless the order states otherwise, a dismissal
> under this paragraph (2) is without prejudice.

Fed. R. Civ. P. 41(a)(2). "[T]he grant or denial of voluntary dismissal without prejudice is a matter

of judicial discretion . . . ." *Ockert v. Union Barge Line Corp.*, 190 F.2d 303, 304 (3d Cir. 1951).

In the Third Circuit, "the general rule is that such a motion should be granted liberally." *Baldinger*

v. Cronin, 535 F. App'x 78, 80 (3d Cir. 2013) (citing *In re Paoli R.R. Yard PCB Litig.*, 916 F.2d

829, 863 (3d Cir. 1990)). An exception to this rule is where "the defendant 'will suffer plain legal

Appx2

prejudice,' beyond the 'mere prospect that [it] will face a subsequent lawsuit.'" *Wi-LAN Inc. v. Sharp Elecs. Corp.*, 2018 WL 914779, at *1 (D. Del. Feb. 15, 2018) (quoting *Reach & Assocs., P.C. v. Dencer*, 2004 WL 253487, at *1 (D. Del. Feb. 9, 2004)). In determining whether legal prejudice will result from dismissal of a claim without prejudice, courts in this circuit consider (1) any excessive and duplicative expense of a second litigation; (2) the effort and expense incurred by a defendant in preparing for trial; (3) the extent to which the pending litigation has progressed; and (4) the claimant's diligence in moving to dismiss. *Wi-LAN*, 2018 WL 914779, at *1; *Reach*, 2004 WL 253487, at *1.

III.   DISCUSSION

When the Court stayed this case in 2021, it was in its infancy. It still is. There is no scheduling order and there has been no discovery.[1] Having considered the factors, the Court will exercise its discretion to grant DivX's request to dismiss the case without prejudice.

NOW THEREFORE, for the reasons set forth above, it is HEREBY ORDERED that Defendant's Motion to Dismiss Without Prejudice (D.I. 65) is GRANTED, and the Complaint is DISMISSED without prejudice. The Clerk of the Court is directed to close the case.
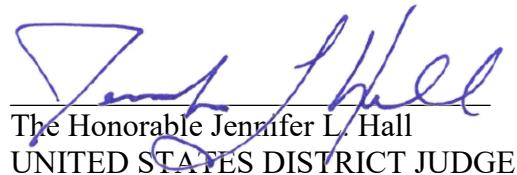
Date: June 4, 2024

The Honorable Jennifer L. Hall
UNITED STATES DISTRICT JUDGE

---

[1] For this reason, I find that a dismissal without prejudice would not result in a significant or duplicative additional expense were DivX to file again. Realtek points out that an extensive record was developed before the ITC (D.I. 69 at 11), but I see no reason why any benefit the ITC record would provide in this case wouldn't be available in any subsequent case.

Realtek also points out that it spent "millions of dollar[s] and fees and costs" in the ITC case. (D.I. 69 at 3.) But if Realtek thinks that DivX acted improperly in the ITC proceeding, Realtek can ask the Commission for relief. Indeed, the record reflects that Realtek sought sanctions in the ITC, and the Commission's decision not to award sanctions is currently on appeal to the Federal Circuit. *Realtek Semiconductor Corporation v. ITC*, No. 23-1095 (Fed. Cir.).

US008832297B2

(12) **United States Patent**
Soroushian et al.

(10) **Patent No.:**   **US 8,832,297 B2**
(45) **Date of Patent:**   **Sep. 9, 2014**

(54) **SYSTEMS AND METHODS FOR PERFORMING MULTIPHASE ADAPTIVE BITRATE STREAMING**

(75) Inventors: **Kourosh Soroushian**, San Diego, CA (US); **Auke van der Schaar**, Los Angeles, CA (US); **Jason Braness**, San Diego, CA (US); **William David Amidei**, San Diego, CA (US)

(73) Assignee: **Sonic IP, Inc.**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/339,992**

(22) Filed: **Dec. 29, 2011**

(65) **Prior Publication Data**

US 2013/0007297 A1   Jan. 3, 2013

Related U.S. Application Data

(60) Provisional application No. 61/502,769, filed on Jun. 29, 2011.

(51) **Int. Cl.**
G06F 15/16	(2006.01)
H04L 29/06	(2006.01)
H04N 21/442	(2011.01)
H04N 21/6587	(2011.01)
H04N 21/845	(2011.01)

(52) **U.S. Cl.**
CPC *H04L 65/4084* (2013.01); *H04L 65/80* (2013.01); *H04L 65/4092* (2013.01); *H04N 21/44209* (2013.01); *H04N 21/6587* (2013.01); *H04N 21/8456* (2013.01); *H04L 65/602* (2013.01)
USPC **709/231**

(58) **Field of Classification Search**
USPC 709/231
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,385,673	B1	5/2002	Demoney	
2010/0235542	A1*	9/2010	Visharam et al.	709/246
2010/0306810	A1*	12/2010	Brooks et al.	725/109
2011/0066673	A1*	3/2011	Outlaw	709/203

FOREIGN PATENT DOCUMENTS

WO   2013002834 A1   1/2013

OTHER PUBLICATIONS

International Search Report and Written Opinion for Application PCT/US2011/68156, Report Completed Apr. 7, 2012, 11 pgs.

* cited by examiner

Primary Examiner — Jason Gee
(74) *Attorney, Agent, or Firm* — KPPB LLP

(57)   **ABSTRACT**

Multiphase adaptive bitrate streaming systems and methods in accordance with embodiments of the invention are disclosed. One embodiment of the invention includes a processor configured to request portions of files. In addition, the processor streams encoded media in a first operational phase utilizing a first set of stream switching conditions. When at least one phase transition criterion is satisfied, the client application configures the processor to transition to a second operational phase utilizing a second set of stream switching conditions.

41 Claims, 6 Drawing Sheets
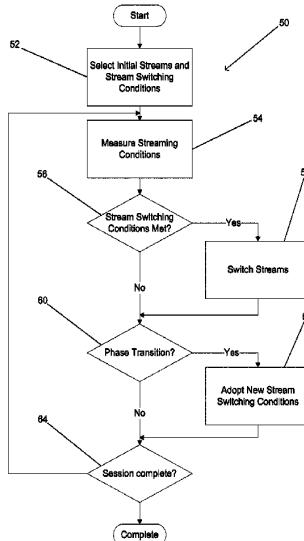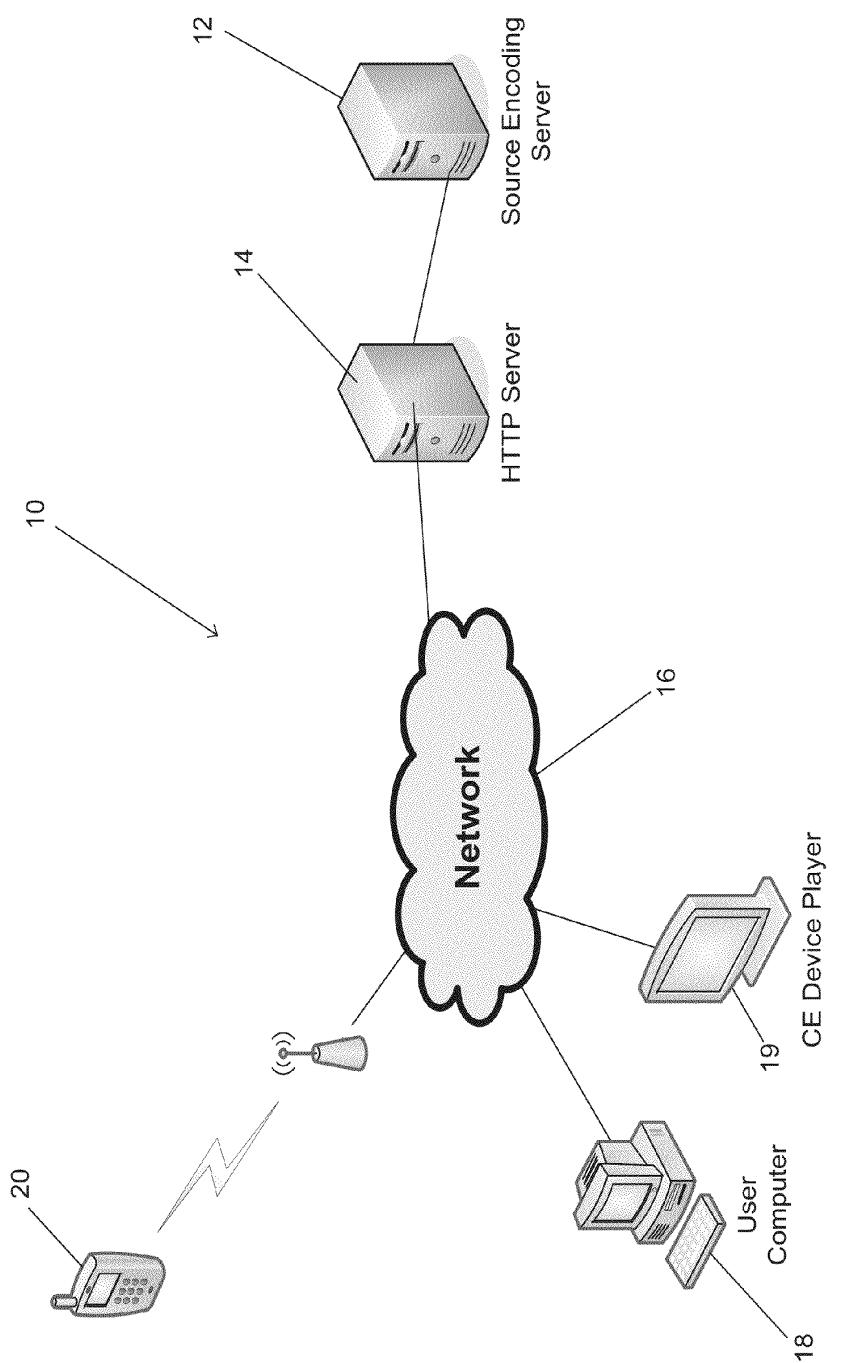
Appx4

FIG. 1

FIG. 2

FIG. 3

FIG. 5

FIG. 4

Appx8
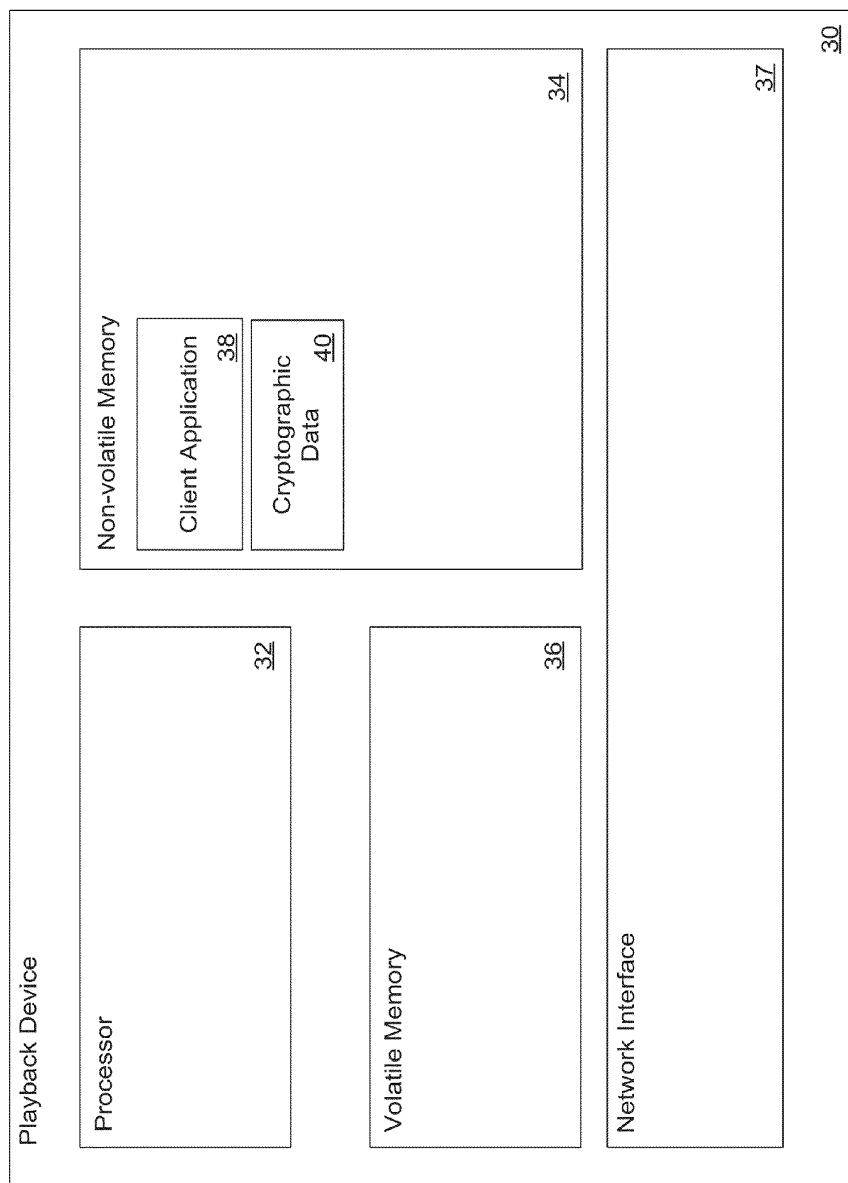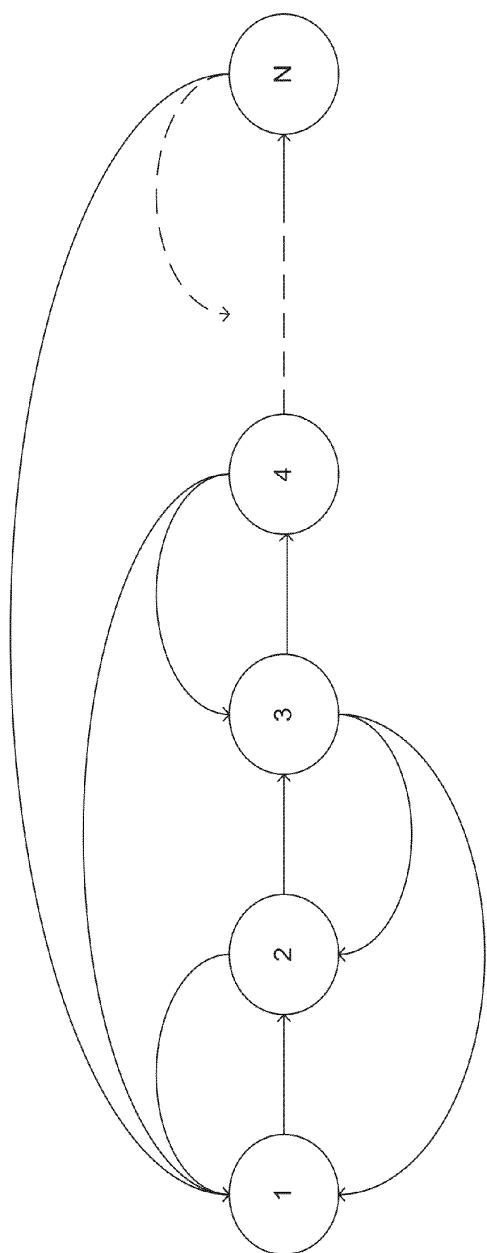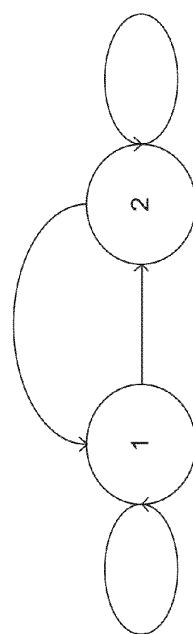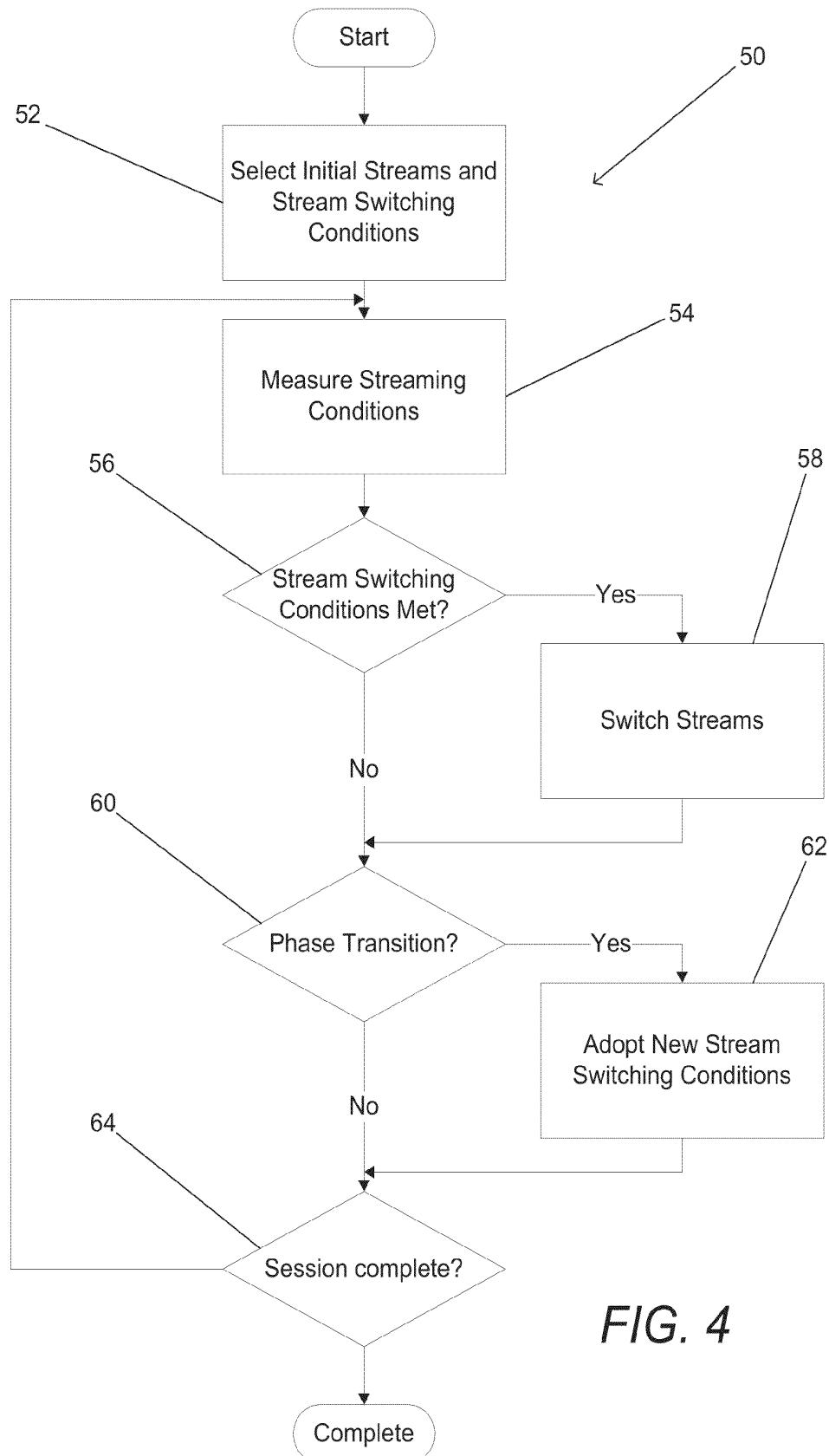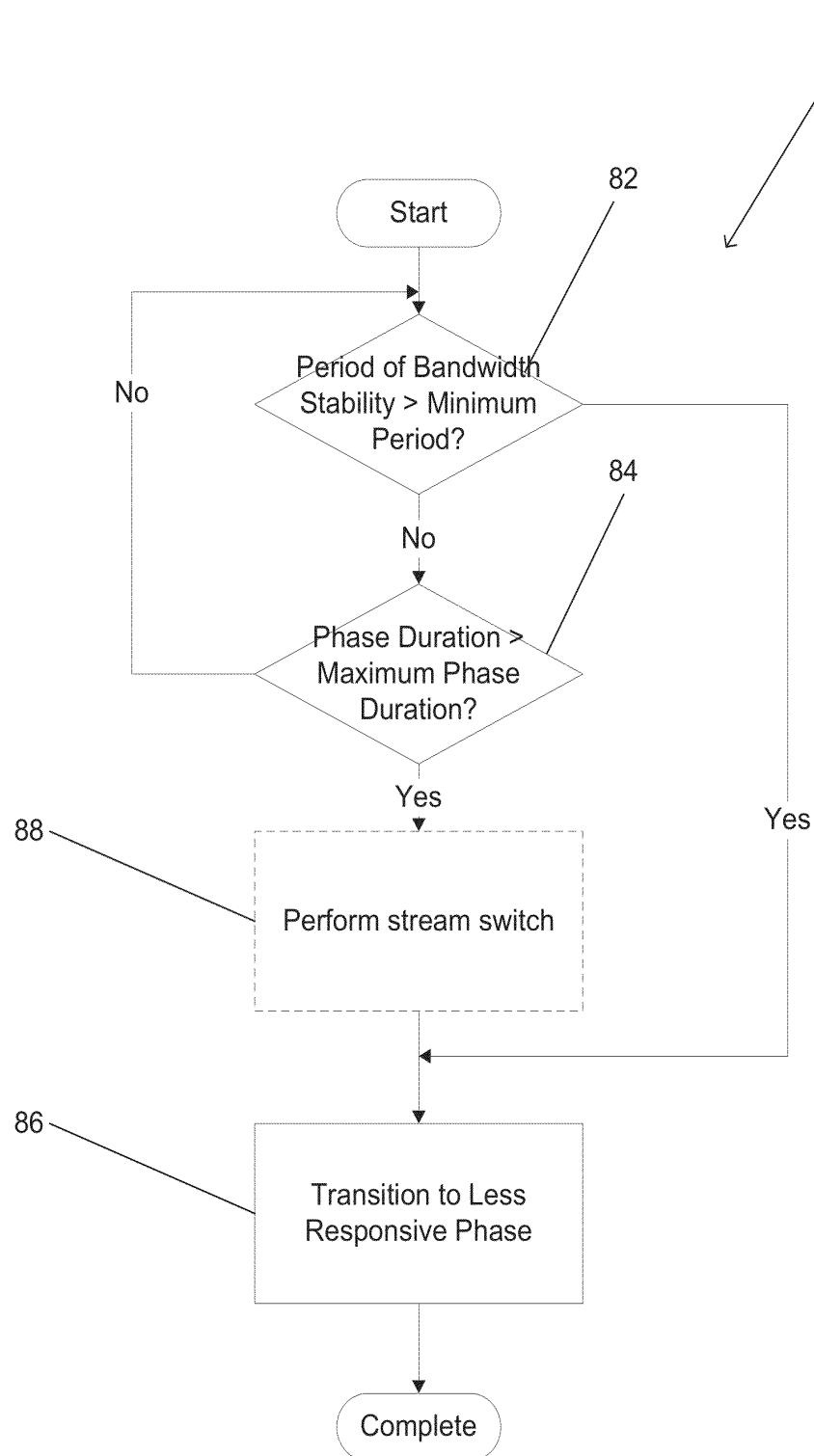
FIG. 6
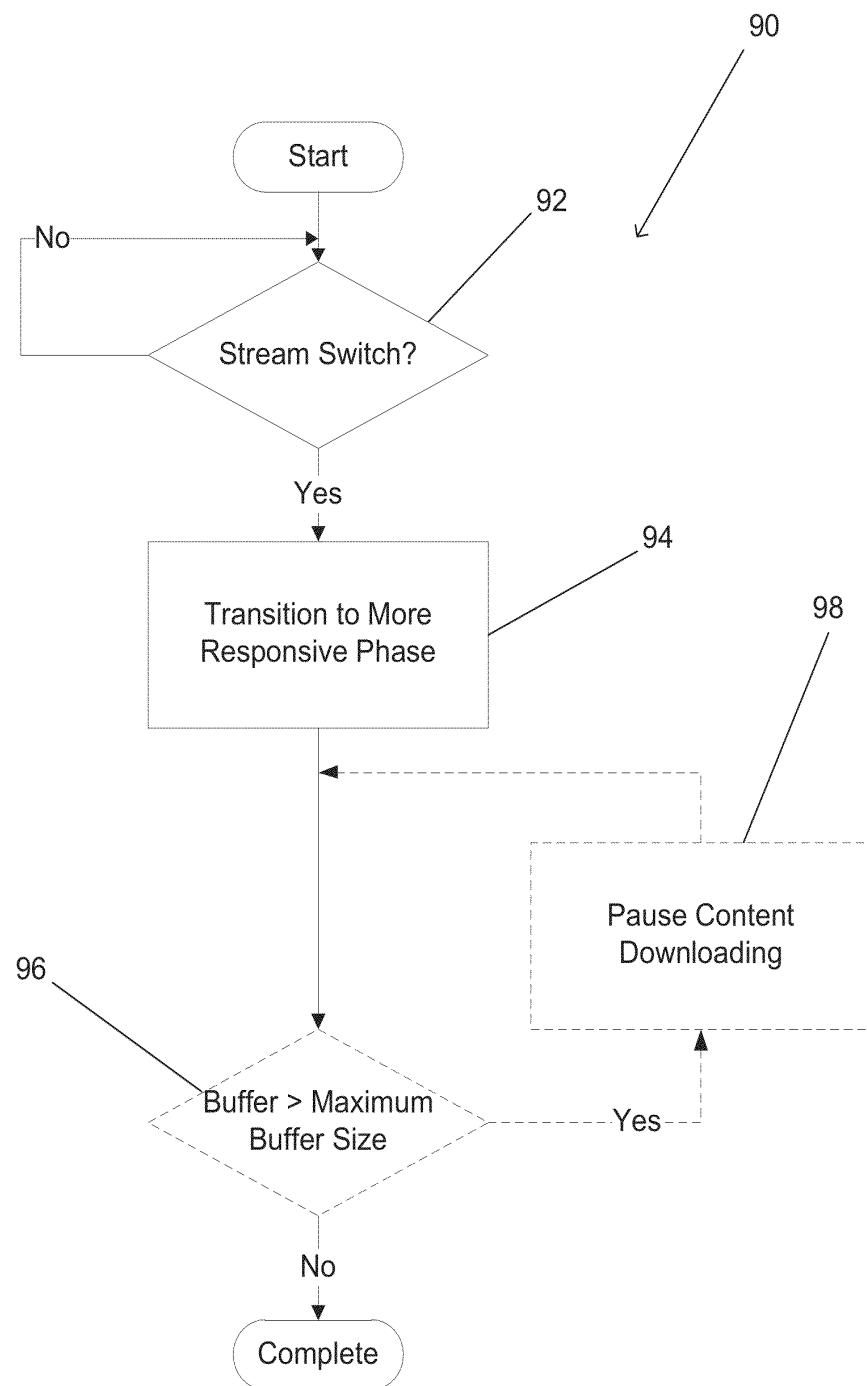
FIG. 7

US 8,832,297 B2

<div style="text-align:center">1</div>

SYSTEMS AND METHODS FOR PERFORMING MULTIPHASE ADAPTIVE BITRATE STREAMING

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application Ser. No. 61/502,769, entitled "Muliphase Adaptive Streaming Algorithm" to Soroushian et al., filed Jun. 29, 2011, the entirety of which is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention generally relates to streaming media and more specifically to stream switching in adaptive bitrate streaming systems.

BACKGROUND

The term streaming media describes the playback of media on a playback device, where the media is stored on a server and continuously sent to the playback device over a network during playback. Typically, the playback device stores a sufficient quantity of media in a buffer at any given time during playback to prevent disruption of playback due to the playback device completing playback of all the buffered media prior to receipt of the next portion of media. Adaptive bit rate streaming or adaptive streaming involves detecting the present streaming conditions (e.g. the user's network bandwidth and CPU capacity) in real time and adjusting the quality of the streamed media accordingly. Typically, the source media is encoded at multiple bit rates and the playback device or client switches between streaming the different encodings depending on available resources.

A common goal of adaptive bitrate streaming is to stream the highest bitrate stream available given the streaming conditions experienced by the playback device without stalls in the playback of media due to underflow. Underflow occurs when the playback device receives streaming media at a lower data rate than the minimum data rate for playing back the stream at the display rate of the playback device. The video used in most adaptive bitrate streaming systems is encoded using variable bit rate encoding, which is typically most efficient. Even though the bitrate of the stream varies in time, the stream is typically described based upon its average bitrate. When variable bitrate encoding is used, the maximum bitrate of the stream is the rate that ensures that no underflow will occur given a certain buffer size. Most playback devices accommodate variation in the size of the encoded frames using a buffer. In the context of video, the buffering delay (which can also be referred to as the seek delay) is the time a playback device waits between starting filling the buffer and commencing playback to prevent underflow (i.e., a certain amount of data is buffered before decoding can start).

Adaptive streaming solutions typically utilize Hypertext Transfer Protocol (HTTP), published by the Internet Engineering Task Force and the World Wide Web Consortium as RFC 2616, to stream media between a server and a playback device. HTTP is a stateless protocol that enables a playback device to request a byte range within a file. HTTP is described as stateless, because the server is not required to record information concerning the state of the playback device requesting information or the byte ranges requested by the playback device in order to respond to requests received from the playback device.

<div style="text-align:center">2</div>

In adaptive streaming systems, the source media is typically stored on a media server as a top level index file pointing to a number of alternate streams that contain the actual video and audio data. Each stream is typically stored in one or more container files. Different adaptive streaming solutions typically utilize different index and media containers. The Synchronized Multimedia Integration Language (SMIL) developed by the World Wide Web Consortium is utilized to create indexes in several adaptive streaming solutions including IIS Smooth Streaming developed by Microsoft Corporation of Redmond, Wash., and Flash Dynamic Streaming developed by Adobe Systems Incorporated of San Jose, Calif. HTTP Adaptive Bitrate Streaming developed by Apple Computer Incorporated of Cupertino, Calif. implements index files using an extended M3U playlist file (.M3U8), which is a text file containing a list of URIs that typically identify a media container file. The most commonly used media container formats are the MP4 container format specified in MPEG-4 Part 14 (i.e. ISO/IEC 14496-14) and the MPEG transport stream (TS) container specified in MPEG-2 Part 1 (i.e. ISO/IEC Standard 13818-1). The MP4 container format is utilized in IIS Smooth Streaming and Flash Dynamic Streaming. The TS container is used in HTTP Adaptive Bitrate Streaming.

SUMMARY OF THE INVENTION

Multiphase adaptive bitrate streaming systems in accordance with embodiments of the invention can transition between different phases in which different stream switching conditions are utilized. One embodiment of the invention includes a processor configured, via a client application, to request portions of files from a remote server. In addition, the client application further configures the processor to commence streaming of the encoded media in a first operational phase utilizing a first set of stream switching conditions by requesting portions of the encoded media from one of the plurality of alternative streams, and measure streaming conditions. When a first set of stream switching conditions is satisfied in the first operational phase, the client application configures the processor to request portions of the encoded media from another of the plurality of alternative streams and when at least one phase transition criterion is satisfied, the client application configures the processor to transition to a second operational phase utilizing a second set of stream switching conditions. Furthermore, when the second set of stream switching conditions is satisfied in the second operational phase, the client application configures the processor to request portions of the encoded media from another of the plurality of alternative streams.

In a further embodiment, the first set of stream switching conditions configure the playback device to respond more rapidly to changes in streaming conditions than when the playback device is configured using the second set of stream switching conditions.

In another embodiment, the second set of stream switching conditions configure the playback device to buffer more content than when the playback device is configured using the first set of stream switching conditions.

In a still further embodiment, the client application configures the processor device to progress through a plurality of operational phases including the first and second operational phases, where a different set of stream switching conditions are utilized during each operational phase.

In still another embodiment, in at least one of the operational phases the client application configures the playback

<div style="text-align:center">**Appx11**</div>

US 8,832,297 B2

3

device to transition to an operational phase having a larger maximum buffer size when at least one phase transition criterion is satisfied.

In a yet further embodiment, in at least one of the operational phases the client application configures the playback device to transition to an operational phase storing a larger amount of content measured in units of time when at least one phase transition criterion is satisfied.

In yet another embodiment, in at least one of the operational phases the client application configures the playback device to transition to an operational phase having a smaller maximum buffer size when at least one phase transition criterion is satisfied.

In a further embodiment again, in at least one of the operational phases the client application configures the playback device to transition to an operational phase storing a smaller amount of content measured in units of time when at least one phase transition criterion is satisfied.

In another embodiment again, the client application configures the playback device to transition to the second operational phase in response to stable streaming conditions for a predetermined period of time.

In a further additional embodiment, the client application determines stable streaming conditions by observing a set of consecutive measurements and determining that the minimum and maximum observed rates fall within a predetermined range.

In another additional embodiment, the client application determines stable streaming conditions by observing the same streaming level for a predetermined amount of time.

In a still yet further embodiment, the client application configures the playback device to transition to the second operational phase in response to the time in which the playback device is in the first operational phase exceeding a predetermined maximum time.

In still yet another embodiment, the client application configures the playback device to select streams appropriate to the second operational phase when the playback device transitions to the second operational phase in response to the time in which the playback device is in the first operational phase exceeding a predetermined maximum time.

In a still further embodiment again, the client application further configures the processor so that when at least one phase transition criteria is satisfied, the playback device transitions from the second operational phase to the first operational phase in which the first set of stream switching conditions are utilized.

In still another embodiment again, the client application configures the playback device to transition from the second operational phase to the first operational phase in response to the second set of stream switching conditions being satisfied such that a stream switch occurs involving the playback device requesting portions of encoded media from a stream having a maximum bitrate that is lower than the maximum bitrate of the stream from which the playback device was requesting portions of the encoded media prior to the stream switch.

In a still further additional embodiment, the client application configures the processor to suspend requesting portions of encoded media from the stream following the stream switch until the amount of buffered media is less than a maximum buffer size that forms part of the first set of stream switching conditions.

In still another additional embodiment, the client application configures the processor to suspend requesting portions of encoded media from the stream following the stream switch until the amount of buffered media measured in units

4

of time is less than a maximum amount of time that forms part of the first set of stream switching conditions.

One embodiment of the method of the invention includes: commencing streaming of the encoded media in a first operational phase utilizing a first set of stream switching conditions by requesting portions of the encoded media from one of the plurality of alternative streams using a playback device; measuring streaming conditions using the playback device; when the first set of stream switching conditions is satisfied in the first operational phase, requesting portions of the encoded media from another of the plurality of alternative streams using the playback device; when at least one phase transition criterion is satisfied, transitioning the playback device to a second operational phase utilizing a second set of stream switching conditions; and when the second set of stream switching conditions is satisfied in the second operational phase, requesting portions of the encoded media from another of the plurality of alternative streams using the playback device.

In a further embodiment of the method of the invention, the first set of stream switching conditions configure the playback device to respond more rapidly to changes in streaming conditions than when the playback device is configured using the second set of stream switching conditions.

In another embodiment of the method of the invention, the second set of stream switching conditions configure the playback device to buffer more content than when the playback device is configured using the first set of stream switching conditions.

A still further embodiment of the method of the invention, also includes progressing the playback device through a plurality of operational phases including the first and second operational phases, where a different set of stream switching conditions are utilized during each operational phase.

Still another embodiment of the method of the invention also includes transitioning the playback device to an operational phase having a larger maximum buffer size when at least one phase transition criterion is met.

A yet further embodiment of the method of the invention also includes transitioning the playback device to an operational phase storing a larger amount of content measured in units of time when at least one phase transition criteria is satisfied.

Yet another embodiment of the method of the invention also includes transitioning the playback device to an operational phase having a smaller maximum buffer size when at least one phase transition criterion is met.

A further embodiment again of the method of the invention also includes transitioning the playback device to an operational phase storing a smaller amount of content measured in units of time when at least one phase transition criterion is satisfied.

In another embodiment again of the method of the invention, the playback device transitions to the second operational phase in response to stable streaming conditions for a predetermined period of time.

In a further additional embodiment of the method of the invention, the playback device transitions to a subsequent operational phase in response to stable streaming conditions for a predetermined period of time.

In another additional embodiment of the method of the invention, the playback device determines stable streaming conditions by observing a set of consecutive measurements and determining that the minimum and maximum observed rates fall within a predetermined range.

US 8,832,297 B2

5   6

In a still yet further embodiment of the method of the invention, the playback device determines stable streaming conditions by observing the same streaming level for a predetermined amount of time.

In still yet another embodiment of the method of the invention, the playback device transitions to the second operational phase in response to the time in which the playback device is in the first operational phase exceeding a predetermined maximum time.

A still further embodiment again of the method of the invention also includes selecting streams appropriate to the second operational phase using the playback device when the playback device transitions to the second operational phase in response to the time in which the playback device is in the first operational phase exceeding a predetermined maximum time.

Still another embodiment again of the method of the invention also includes when at least one phase transition criterion is satisfied, transitioning the playback device to the first operational phase in which the first set of stream switching conditions are utilized.

A still further additional embodiment of the method of the invention also includes transition the playback device from the second operational phase to the first operational phase in response to the second set of stream switching conditions being satisfied such that a stream switch occurs involving the playback device requesting portions of encoded media from a stream having a maximum bitrate that is lower than the maximum bitrate of the stream from which the playback device was requesting portions of the encoded media prior to the stream switch.

Still another additional embodiment of the method of the invention also includes suspending requests from the playback device for portions of encoded media from the stream following the stream switch until the amount of buffered media is less than a maximum buffer size that forms part of the first set of stream switching conditions.

A yet further embodiment again of the method of the invention also includes suspending requests from the playback device for portions of encoded media from the stream following the stream switch until the amount of buffered media measured in units of time is less than a maximum amount of time that forms part of the first set of stream switching conditions.

Yet another embodiment again of the method of the invention also includes when at least one phase transition criterion is satisfied, transitioning the playback device to the previous operational phase in which the corresponding enumeration of the set of stream switching conditions are utilized.

A yet further additional embodiment of the method of the invention also includes transition the playback device from an operational phase greater than the first to the previous operational phase in response to the corresponding enumeration of the set of stream switching conditions being satisfied such that a stream switch occurs involving the playback device requesting portions of encoded media from a stream having a maximum bitrate that is lower than the maximum bitrate of the stream from which the playback device was requesting portions of the encoded media prior to the stream switch.

Yet another additional embodiment of the method of the invention also includes suspending requests from the playback device for portions of encoded media from the stream following the stream switch until the amount of buffered media is less than a maximum buffer size that forms part of the previous set of stream switching conditions.

A further additional embodiment again of the method of the invention also includes suspending requests from the playback device for portions of encoded media from the stream following the stream switch until the amount of buffered media measured in units of time is less than a maximum amount of time that forms part of the previous set of stream switching conditions.

Another further embodiment of the invention includes: commencing streaming of the encoded media in a first operational phase utilizing a first set of stream switching conditions by requesting portions of the encoded media from one of the plurality of alternative streams; measuring streaming conditions; when the first set of stream switching conditions is satisfied in the first operational phase, requesting portions of the encoded media from another of the plurality of alternative streams; when at least one phase transition criterion is satisfied, transitioning to a second operational phase utilizing a second set of stream switching conditions; and when the second set of stream switching conditions is satisfied in the second operational phase, requesting portions of the encoded media from another of the plurality of alternative streams.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a network diagram of a media streaming system in accordance with an embodiment of the invention.

FIG. 2 conceptually illustrates a playback device configured to perform multiphase adaptive bitrate streaming in accordance with an embodiment of the invention.

FIG. 3 conceptually illustrates multiple operational phases of a playback device configured to perform multiphase adaptive bitrate streaming in accordance with an embodiment of the invention.

FIG. 4 is flow chart illustrating a process for performing multiphase adaptive bitrate streaming in accordance with an embodiment of the invention.

FIG. 5 conceptually illustrates the operational phases of a two phase adaptive bitrate streaming system in accordance with an embodiment of the invention.

FIG. 6 is a flow chart illustrating a process for determining when to transition from an operational phase in which a playback device's stream switching decisions are more response to variations in streaming conditions to an operational phase in which the playback device's stream switching decisions are less responsive to variations in streaming conditions in accordance with an embodiment of the invention.

FIG. 7 is a flow chart illustrating a process for determining when to transition from an operational phase in which the playback device's stream switching decisions are less responsive to variations in streaming conditions to an operational phase in which a playback device's stream switching decisions are more response to variations in streaming conditions in accordance with an embodiment of the invention.

DETAILED DISCLOSURE OF THE INVENTION

Turning now to the drawings, multiphase adaptive bitrate streaming systems and methods in accordance with embodiments of the invention are illustrated. Adaptive bitrate streaming systems typically provide a number of alternative streams of video encoded at different maximum bitrates. As streaming conditions change, a playback device can switch between streams to prevent disruption in the playback of the content. Typically, adaptive bitrate streaming systems define a set of conditions that determine whether the playback device continues requesting content for playback, or whether the playback device switches to lower or higher bitrate stream(s). These conditions can be referred to as stream switching conditions. The stream switching conditions used by the play-

US 8,832,297 B2

7   8

back device can cause the playback device to react very quickly to changes in the streaming conditions and buffer less content. Alternatively, the stream switching conditions applied by the playback device may cause the playback device to buffer more content and react more slowly to streaming condition changes to ride out temporary bandwidth fluctuations.

In many embodiments of the invention, playback devices are configured to progress through multiple operational phases in which different stream switching conditions are applied by the playback device. These operational phases may be discrete phases or can be a continuum in which the stream switching continuously change. A system where the playback devices progresses through multiple operational phases in which different stream switching conditions are applied by the playback device can be referred to as a multiphase adaptive bitrate streaming system. In such a system, the same stream switching conditions or heuristics are not applied throughout the duration of the streaming of a particular piece of content. Instead, the stream switching conditions can change over time based upon a variety of factors including (but not limited to) duration of playback of the content, time since last stream switch, duration within an operation phase, buffered content and/or the stability of the streaming conditions experienced during playback. While the decision to switch between streams is typically dependent upon a change in streaming conditions, the decision to switch between phases (i.e. the set of stream switching conditions to apply) can be a function of stability in streaming conditions. Multiphase adaptive bitrate streaming systems and methods for performing multiphase adaptive bitrate streaming of multimedia content in accordance with embodiments of the invention are discussed further below.

Multiphase Streaming System Architecture

A multiphase adaptive bitrate streaming system in accordance with an embodiment of the invention is illustrated in FIG. **1**. The multiphase adaptive bitrate streaming system **10** includes a source encoder **12** configured to encode source media as a number of alternative streams. In the illustrated embodiment, the source encoder is a server. In other embodiments, the source encoder can be any processing device including a processor and sufficient resources to perform the transcoding of source media (including but not limited to video, audio, and/or subtitles). The source encoding server **12** typically generates a top level index to a plurality of container files containing the streams, at least a plurality of which are alternative streams. Alternative streams are streams that encode the same media content in different ways. In many instances, alternative streams encode media content (such as but not limited to video) at different maximum bitrates. In a number of embodiments, the alternative streams are encoded with different resolutions and/or at different frame rates. The top level index file and the container files are uploaded to an HTTP server **14**. In other embodiments, the server is not an HTTP server but is a server configured to implement any stateless or stateful protocol including but not limited to an RTSP server. Although the source encoding server **12** is described above as generating the top level index file, in many embodiments the top level index file is dynamically generated in response to a request for a specific piece of content by a playback device. Systems and methods for encoding source media for adaptive bitrate streaming are disclosed in U.S. patent application Ser. No. 13/221,682 entitled "Systems and Methods for Adaptive Bitrate Streaming of Media Stored in Matroska Container Files Using Hypertext Transfer Protocol" to Braness et al., filed Aug. 30, 2011, the disclosure of which is incorporated herein by reference in its entirety.

In the illustrated embodiment, a variety of playback devices use HTTP or another appropriate stateless protocol to request portions of a top level index file and the container files via a network **16** such as the Internet. Prior to a playback device performing adaptive bitrate streaming using portions of media from alternative streams contained within the container files, a bandwidth probe can be performed by the playback device to determine available bandwidth. Once the bandwidth probe has been completed, the playback device can utilize data within the top level index including (but not limited to) the maximum bitrate of each of the available streams to determine the initial streams from which to commence requesting portions of encoded media as part of an adaptive bitrate streaming process.

Once playback of content from the initial set of streams commences, the playback device utilizes the top level index to perform adaptive bitrate streaming of the content in response to changes in streaming conditions. In a multiphase adaptive bitrate streaming system, the playback device can progress through a series of operational phases in which the playback device responds differently in each phase to changes in the streaming conditions. In a number of embodiments, stability in streaming conditions or improving streaming conditions can result in a transition to a phase in which the playback device assumes stable operating conditions, buffers more content, and is less responsive to fluctuations in streaming conditions. In many embodiments, a deterioration in streaming conditions that results in a stream switch to a set of streams requiring less bandwidth results in the playback device transitioning to a phase in which the playback device assumes unstable operating conditions, buffers less content, and responds rapidly to variations in streaming conditions.

In the illustrated embodiment, playback devices include personal computers **18**, CE players **19**, and mobile phones **20**. In other embodiments, playback devices can include consumer electronics devices such as DVD players, Blu-ray players, televisions, set top boxes, video game consoles, tablets, and other devices that are capable of connecting to a server via HTTP and playing back encoded media. The basic architecture of a playback device in accordance with an embodiment of the invention is illustrated in FIG. **2**. The playback device **30** includes a processor **32** in communication with non-volatile memory **34** and volatile memory **36**. The playback device **30** also includes a network interface **37** for communicating with external devices via a network connection. In the illustrated embodiment, the non-volatile memory includes a client application **38** that configures the processor and the playback device to perform multiphase adaptive bitrate streaming. The non-volatile memory **34** also includes cryptographic data **40** that can be utilized in accessing encrypted content. In addition, the playback device can include audio and/or video rendering capabilities and/or audio and video outputs (not shown). Although a specific playback device architecture is illustrated in FIG. **2**, any of a variety of architectures including architectures where the client application is located on disk or some other form of storage and is loaded into volatile memory at runtime can be utilized to implement playback devices for use in multiphase adaptive bitrate streaming systems in accordance with embodiments of the invention. Furthermore, any of a variety of system architectures including (but not limited) to the system architecture illustrated in FIG. **1** can be utilized to perform multiphase adaptive bitrate streaming in accordance with embodiments of the invention.

Multiple Operational Phases

Playback devices in accordance with embodiments of the invention can progress through a series of operational phases in which the playback device responds differently in each

9

phase to changes in the streaming conditions. The operational phases of a playback device in accordance with an embodiment of the invention are conceptually illustrated in FIG. **3**. At any time during the streaming of content, the playback device occupies a specific operational phase or state. In the illustrated embodiment, the playback device can occupy any of operational phases **1** through N. In each operational phase, the playback device can remain in the present operational phase, transition to a new phase or transition back to a previous phase. Typically, the playback device moves to a new operational phase or "increases" operational phase in response to an increase in the stability of the streaming conditions, and the playback device moves back to a previous operational phase or "decreases" operational phase in response to a decrease in the stability of the streaming conditions. Depending upon initial bandwidth measurements and the requirements of a specific application, the system may support starting at a higher phase and transitions involving skipping over phases. In the illustrated embodiment, the playback device progresses through each of the phases and can fall by a single phase, more than one phase or can fall back to the initial phase. As noted above, decisions concerning transitioning between operational phases are typically independent of decisions to switch between phases. Although in many embodiments, a decision to switch stream(s) to stream(s) having lower bandwidth requirements also results in a transition in operational phase. Although specific transitions are illustrated in FIG. **3**, any of a variety of sets of transitions between operational phases can be defined as appropriate to the requirements of a specific application in accordance with embodiments of the invention. Furthermore, multiphase adaptive bitrate streaming systems in accordance with embodiments of the invention can utilize as few as two phases. Indeed, the combination of phases, the permitted transitions between phases and the conditions for transitioning between phases are only limited by the requirements of a specific application.

Multiphase Adaptive Bitrate Streaming

As discussed above, multiphase adaptive bitrate streaming can be performed utilizing any number of operational phases and criteria for transitioning between operational phases. A generalized process for playback of content in a multiphase adaptive bitrate streaming system in accordance with embodiments of the invention is illustrated in FIG. **4**. The process **50** commences by selecting (**52**) initial streams and stream switching conditions. Instead of simply starting requesting the lowest bitrate stream(s), a playback device can perform an initial bandwidth probe to estimate the available bandwidth and select initial streams with which to commence streaming based upon the bandwidth estimate. Processes for selecting initial stream(s) are disclosed in U.S. patent application Ser. No. 13/251,061, entitled "Systems and Methods for Determining Available Bandwidth and Performing Initial Stream Selection When Commencing Streaming Using Hypertext Transfer Protocol" to Van Der Schaar et al., filed Sep. 30, 2011. The disclosure of U.S. patent application Ser. No. 13/251,061 is incorporated herein by reference in its entirety. The initial stream switching conditions that are selected can be selected by default (e.g. the system always commences in predetermined phase) or can be selected based upon the measurements utilized to select the initial streams (whether performed immediately prior to commencement of streaming or based upon historical measurements).

Once initial streams and stream switching conditions are selected, the process illustrated in FIG. **4** involves measuring (**54**) streaming conditions as content is received and played back by a playback device, and then determining (**56**)

10

whether stream switching conditions are met. When the stream switching conditions are met (either to switch to streams having a higher combined maximum bitrate or to switch to streams that have a lower combined maximum bitrate), the playback device performs (**58**) the appropriate stream switch(es). The playback device also determines (**60**) whether the conditions are met for a transition between operational phases. In the event that the conditions are met, the playback device transitions between operational phases, which involves adopting (**62**) a different set of stream switching conditions. The playback device determines (**64**) whether the session is complete. If not, the process loops back to measuring (**54**) streaming conditions and performing stream switches and phase transitions as appropriate. When the session is complete, the process terminates.

Although a specific process for performing multiphase adaptive bitrate streaming is illustrated in FIG. **4**, any of a variety of processes that involve the adoption of different sets of stream switching conditions based upon any of a variety of factors including (but not limited to) the measured streaming conditions can be utilized in accordance with embodiments of the invention.

Transitioning to a Less Responsive Phase

In several embodiments, the decision to transition from a phase in which the playback device reacts rapidly to changes in streaming conditions to a phase in which it reacts more slowly considers a variety of factors including (but not limited to) any combination of duration of playback of the content, time since last stream switch, duration within an operational phase, the amount of buffered content and/or the stability of the streaming conditions experienced during playback. In a number of embodiments, a transition is made when the bandwidth has been stable for a predetermined period of time. Stability may be defined in a number of ways; for example, it can be defined as the periodic sampling of the bandwidth at a specific interval (such as every 1 second), and the difference between the highest measured rate and lowest measured rates between several consecutive intervals (for example 10 seconds) to be within a certain range (such as 10%) of one another. Another measure of stability may be if streaming has continued using the same level for a predetermined interval (for example 15 seconds). In other embodiments, any of a variety of different stability measures can be utilized. In several embodiments, the playback device is only permitted to remain within an operational phase a predetermined period of time without transitioning to a less responsive operational phase. In many embodiments, when a playback device transitions to a less responsive phase after the maximum period of time in which the playback device is allowed to remain in the previous phase elapses, the playback device also selects stream(s) that will enable sufficient buffering of content to avoid stream switches in response to volatility on the streaming conditions as part of the transition. In another group of embodiments, the playback device will not transition until the playback device has occupied a particular operational phase for a predetermined period of time. In systems that include more than two phases, the predetermined period of time can be different depending upon the phase to which the playback device will transition. In a further set of embodiments, the playback device transitions to a phase in which the playback device reacts more slowly to changes in streaming conditions when a predetermined amount of content is buffered.

Transitioning to a More Responsive Phase

Generally, a transition from a phase in which the playback device reacts more slowly to changes in streaming conditions to a phase in which the playback device reacts more rapidly to changes in streaming conditions occurs in response to the

US 8,832,297 B2

11 12

playback device switching to stream(s) having a lower maximum bandwidth requirement. In multiphase adaptive bitrate streaming systems having more than two phases, the transition is typically a transition to the previous phase, or to the phase in which the playback device is most responsive to changes in streaming conditions (often referred to as the "lowest" phase). The buffering requirements typically increase with successively higher phases of operation; for example, in a two-phase system, the first phase may buffer a maximum of 10 seconds of audio, video, and metadata content, and the second phase may buffer as much content as allowable by the system memory. In a multi-phase system, the first phase may buffer a maximum of 10 seconds of audio, video, and metadata content, the next phase a maximum of 20 seconds of content and so forth, and the last phase buffering as much content as allowable by the system memory. It is possible to use a physical memory buffer limitation for each phase, rather than the maximum duration of the content. In other embodiments, any of a variety of buffering conditions and/or constraints can be imposed as appropriate to the requirements of a specific application. When a playback device transitions to a lower phase (i.e. a more responsive phase), the playback device can reduce the amount of buffered content below the maximum allowed in the lower phase by pausing the downloading of new content until the buffering levels for the lower phase have been met.

The stream switching conditions that can be applied by a playback device during different operational phases and the criteria for transitioning between the phases in accordance with embodiments of the invention are discussed further below with respect to a two phase adaptive bitrate streaming system.

A Two Phase Adaptive Bitrate Streaming System

Multiphase adaptive bitrate streaming systems in accordance with embodiments of the invention can support multiple operational phases in which playback devices respond differently in each phase to changes in the streaming conditions. A comparatively simple implementation of a multiphase adaptive bitrate streaming system is to utilize two operational phases. A first phase that utilizes stream switching conditions that cause the playback device to react very quickly to changes in the streaming conditions, and a second phase in which the stream switching conditions cause the playback device to buffer more content and react more slowly to changes in streaming conditions. For example, the system may behave differently for a temporary change in the available bandwidth due to the sharing of bandwidth with another activity (such as downloading of an MP3 music file in a home while utilizing adaptive streaming), where in the case of a phase which allows quick reactions, the streaming quality may degrade as soon as a drop in the bandwidth throughput is detected, but in a case which allows slower reaction, the streaming player may consume a certain amount of the buffered content first, prior to allowing a switch to a lower streaming level. In several embodiments, the playback device is configured to transition between the two phases based upon the stability of the streaming conditions.

Operational phases of a two phase adaptive bitrate streaming system in accordance with embodiments of the invention is illustrated in FIG. **5**. The two illustrated operational phases correspond to a first operational phase (i.e. phase **1**) in which a first set of stream switching conditions is utilized that cause the playback device to react very quickly to changes in the streaming conditions and a second operational phase (i.e. phase **2**) in which a second set of stream switching conditions is utilized that cause the playback device to buffer more content and react more slowly to changes in streaming conditions. In each phase, the playback device can remain in the operational phase or transition to the other operational phase.

Any of a variety of criteria can be utilized when determining whether to perform a specific phase transition. In many embodiments, the decision to switch from a phase in which the playback device reacts rapidly to changes in streaming conditions (e.g. phase **1** in FIG. **5**) to a phase in which the playback device reacts more slowly to changes in streaming conditions (e.g. phase **2** in FIG. **5**) is performed based upon the stability of the streaming conditions and/or a variety of other factors. Indeed, in many embodiments an initial measurement of the available bandwidth may suggest that the system can start in a phase in which the playback device reacts more slowly to changes in streaming conditions (e.g. phase **2** in FIG. **5**). A process for determining whether to transition from a phase in which the playback device reacts rapidly to changes in streaming conditions to a phase in which the playback device reacts more slowly to changes in streaming conditions is illustrated in FIG. **6**. The process **80** involves determining (**82**) whether a minimum period of bandwidth stability has been observed or (**84**) whether the phase duration has exceeded a maximum permitted phase duration. If either condition is satisfied, then a transition (**86**) to a phase in which the playback device is less responsive to streaming conditions occurs. If neither condition is satisfied, then the process repeats until a phase transition occurs. In a number of embodiments, a phase transition that occurs as a result of the phase duration exceeding a maximum permitted phase duration also precipitates a stream switch (**88**) to stream(s) appropriate to the new phase given the observed volatility in streaming conditions. This may be achieved by selecting the average bandwidth that was observed during the initial phase, and switching to an appropriate level; alternatively, a percentage value of the latest N bandwidth samples measured within a certain period may be selected (such as 0.70 times the average of the last 5 bandwidth measurements, taken at regular intervals of 1 seconds each). In other embodiments, any of a variety of conditions can be utilized appropriate to a specific application. Although a specific process is illustrated in FIG. **6**, any of a variety of processes can be utilized for determining when to transition from a phase in which the playback device reacts rapidly to changes in streaming conditions to a phase in which the playback device reacts more slowly to changes in streaming conditions as appropriate to the requirements of a specific application in accordance with embodiments of the invention.

In a number of embodiments, the decision to switch from a phase in which the playback device reacts more slowly to changes in streaming conditions (e.g. phase **2** in FIG. **5**) to a phase in which the playback device reacts rapidly to changes in streaming conditions (e.g. phase **1** in FIG. **5**) is performed based upon the occurrence of a stream switch to a stream(s) having a lower maximum bandwidth requirement. A process for determining whether to transition from a phase in which the playback device reacts slowly to changes in streaming conditions to a phase in which it reacts more rapidly to changes in streaming conditions is illustrated in FIG. **7**. The process **90** includes determining (**92**) whether a stream switch has occurred and when a stream switch has occurred, transitioning (**94**) to a phase in which the playback device is more responsive to changes in streaming conditions. In many embodiments, when the playback device transitions (**94**) to a more responsive phase, the playback device determines (**96**) whether the amount of buffered content exceeds the maximum amount of buffered content allowed in the new phase. In the event that the amount of buffered content exceeds the maximum amount of buffered content allowed in the new

US 8,832,297 B2

13

phase, the playback device can pause (**98**) downloading of content until the buffering requirements are met. Although a specific process is illustrated in FIG. **7**, any of a variety of processes for determining whether to transition from a phase in which the playback device reacts slowly to changes in streaming conditions to a phase in which it reacts more rapidly to changes in streaming conditions can be utilized as appropriate to the requirements of a specific application in accordance with embodiments of the invention. Furthermore, although the processes shown in FIGS. **6** and **7** are discussed with reference to transitions between two phases, similar processes considering the same or similar criteria for determining whether to perform phase transitions can be utilized in multiphase adaptive bitrate streaming systems including three or more phases.

Although the present invention has been described in certain specific aspects, many additional modifications and variations would be apparent to those skilled in the art. It is therefore to be understood that the present invention may be practiced otherwise than specifically described, including utilizing playback devices that support a greater number or lesser number of operational phases and that transition between phases in ways different to the specific examples discussed above and/or playback devices where the set of streaming switching conditions utilized by the playback device are continuously changing, without departing from the scope and spirit of the present invention. Thus, embodiments of the present invention should be considered in all respects as illustrative and not restrictive.

What is claimed:

1. A playback device configured to perform multiphase adaptive bitrate streaming by requesting portions of encoded media from a plurality of alternative streams of encoded media that are encoded at different maximum bitrates in response to changes in streaming conditions, the playback device comprising:

a processor configured, via a client application, to request portions of files from a remote server;

wherein the client application further configures the processor to:

commence streaming of the encoded media in a first operational phase utilizing a first set of stream switching conditions by requesting portions of the encoded media from one of the plurality of alternative streams encoded at a specified maximum bitrate;

measure streaming conditions for receiving the requested portions of the encoded media from a current one of the plurality of alternate streams having a current maximum bitrate;

determine when a first set of stream switching conditions is satisfied in a first operational phase by the measured streaming conditions;

request portions of the encoded media from another one of the plurality of alternative streams encoded at a maximum bitrate that is different than the current maximum bitrate in response to the determination that the first set of stream switching conditions are satisfied;

determine when at least one phase transition criterion of the first operational phase is satisfied by the measured streaming conditions;

transition to a second operational phase utilizing a second set of stream switching conditions in response to the determination that the at least one transition criterion is satisfied;

14

determine when the second set of stream switching conditions is satisfied in the second operational phase by the measured streaming conditions; and

request portions of the encoded media from another one of the plurality of alternative streams encoded at a maximum bitrate that is different from the current maximum bitrate in response to the determination that the second set of stream switching conditions are satisfied.

2. The playback device of claim **1**, wherein the first set of stream switching conditions configure the playback device to respond more rapidly to changes in streaming conditions than when the playback device is configured using the second set of stream switching conditions.

3. The playback device of claim **1**, wherein the second set of stream switching conditions configure the playback device to buffer more content than when the playback device is configured using the first set of stream switching conditions.

4. The playback device of claim **1**, wherein the client application configures the processor device to progress through a plurality of operational phases including the first and second operational phases, where a different set of stream switching conditions are utilized during each of the plurality of operational phases.

5. The playback device of claim **4**, wherein in at least one of the plurality of operational phases the client application configures the playback device to transition to another one of the plurality of operational phases having a larger maximum buffer size when at least one phase transition criterion is satisfied.

6. The playback device of claim **4**, wherein in at least one of the plurality of operational phases the client application configures the playback device to transition to another one of the plurality of operations phases that stores a larger amount of content measured in units of time when at least one phase transition criterion is satisfied.

7. The playback device of claim **4**, wherein in at least one of the plurality of operational phases the client application configures the playback device to transition to another one of the plurality of operational phases having a smaller maximum buffer size when at least one phase transition criterion is satisfied.

8. The playback device of claim **4**, wherein in at least one of the plurality of operational phases the client application configures the playback device to transition to another one of a plurality of operational phases storing a smaller amount of content measured in units of time when at least one phase transition criterion is satisfied.

9. The playback device of claim **1**, wherein the client application configures the playback device to transition to the second operational phase in response to a determination that the streaming conditions are stable for a predetermined period of time.

10. The playback device of claim **9**, wherein the client application determines streaming conditions are stable by observing a set of consecutive measurements and determining that the minimum and maximum observed rates fall within a predetermined range.

11. The playback device of claim **9**, wherein the client application determines streaming conditions are stable by observing the same streaming level for a predetermined amount of time.

12. The playback device of claim **1**, wherein the client application configures the playback device to transition to the second operational phase in response to a determination that the time in which the playback device is in the first operational phase has exceeded a predetermined maximum time.

US 8,832,297 B2

15

16

13. The playback device of claim 12, wherein the client application configures the playback device to select streams from the plurality of alternative streams appropriate to the second operational phase when the playback device transitions to the second operational phase in response to the determination that the time in which the playback device is in the first operational phase has exceeded the predetermined maximum time.

14. The playback device of claim 1, wherein the client application further configures the processor to determine when at least one phase transition criteria of the second operational phase is satisfied by the measured streaming conditions and to transition from the second operational phase to the first operational phase in which the first set of stream switching conditions are utilized in response to the determination that the at least one phase transition criteria is satisfied.

15. The playback device of claim 1, wherein the client application configures the playback device to transition from the second operational phase to the first operational phase in response to a determination that the second set of stream switching conditions is satisfied such that a stream switch occurs involving the playback device requesting portions of encoded media from one of the plurality of alternative streams that is encoded with a maximum bitrate that is lower than the maximum bitrate of the current one of the plurality of alternative streams from which the playback device was requesting portions of the encoded media prior to the stream switch.

16. The playback device of claim 15, wherein the client application configures the processor to suspend requesting portions of encoded media from a stream following a stream switch until the amount of buffered media is less than a maximum buffer size that forms part of the first set of stream switching conditions.

17. The playback device of claim 15, wherein the client application configures the processor to suspend requesting portions of encoded media from a stream following a stream switch until the amount of buffered media measured in units of time is less than a maximum amount of time that forms part of the first set of stream switching conditions.

18. A method of performing multiphase adaptive bitrate streaming by requesting portions of encoded media from a plurality of alternative streams of encoded media that are encoded at different maximum bitrates in response to changes in streaming conditions, the method comprising:

commencing streaming of the encoded media in a first operational phase utilizing a first set of stream switching conditions by requesting portions of the encoded media from one of the plurality of alternative streams encoded at a specified maximum bit rate using a playback device;

measuring streaming conditions for receiving the requested portions of the encoded media from a current one of the plurality of alternative streams encoded at a current maximum bitrate using the playback device;

determining when the first set of stream switching conditions is satisfied in a first operational phase by the measured streaming conditions;

requesting portions of the encoded media from another one of the plurality of alternative streams encoded at a maximum bitrate that is different from the current maximum bitrate in response to a determination that the first set of streaming conditions is satisfied using the playback device;

determining when at least one phase transition criterion of the first operational phase is satisfied by the measured streaming conditions;

transitioning the playback device to a second operational phase utilizing a second set of stream switching conditions in response to a determination that the at least one phase transition criterion is satisfied;

determining when the second set of stream switching conditions is satisfied by the measured streaming conditions in the second operational phase;

requesting portions of the encoded media from another one of the plurality of alternative streams encoded at a maximum bitrate than is different from the current maximum bitrate using the playback device.

19. The method of claim 18, wherein the first set of stream switching conditions configure the playback device to respond more rapidly to changes in streaming conditions than when the playback device is configured using the second set of stream switching conditions.

20. The method of claim 18, wherein the second set of stream switching conditions configure the playback device to buffer more content than when the playback device is configured to buffer using the first set of stream switching conditions.

21. The method of claim 18, further comprising progressing the playback device through a plurality of operational phases including the first and second operational phases, where a different set of stream switching conditions are utilized during each of the plurality of operational phases.

22. The method of claim 21, further comprising transitioning the playback device to a second one of the plurality of operational phases having a larger maximum buffer size than a current one of the plurality of operation phases when at least one phase transition criterion of the current one of the plurality of operation phases is met.

23. The method of claim 21, further comprising transitioning the playback device to one of the plurality of operation phases storing a larger amount of content measured in units of time size than a current one of the plurality of operation phases when at least one phase transition criteria of the current one of the plurality of operation phases is satisfied.

24. The method of claim 21, further comprising transitioning the playback device to one of the plurality of operation phases having a smaller maximum buffer size than a current one of the plurality of operation phases when at least one phase transition criterion of the current one of the plurality of operation phases is met.

25. The method of claim 21, further comprising transitioning the playback device to one of the plurality of operation phases storing a smaller amount of content measured in units of time than a current one of the plurality of operation phases when at least one phase transition criterion of the current one of the plurality of operation phases is satisfied.

26. The method of claim 18, wherein the playback device transitions from the first operational phase to the second operational phase in response to stable streaming conditions for a predetermined period of time.

27. The method of claim 24, wherein the playback device transitions to a subsequent operational phase in response to a determination that streaming conditions are stable for a predetermined period of time.

28. The method of claim 18, wherein the playback device determines streaming conditions are stable by observing a set of consecutive measurements and determining that the minimum and maximum observed rates fall within a predetermined range.

29. The method of claim 18, wherein the playback device determines streaming conditions are stable by observing the same streaming level for a predetermined amount of time.

US 8,832,297 B2

17

30. The method of claim **18**, wherein the playback device transitions to the second operational phase in response to a determination that the time in which the playback device is in the first operational phase has exceeded a predetermined maximum time.

31. The method of claim **26**, further comprising selecting streams from the plurality of alternative streams appropriate to the second operational phase using the playback device when the playback device transitions to the second operational phase in response to the determination that the time in which the playback device is in the first operational phase has exceeded a predetermined maximum time.

32. The method of claim **18**, further comprising determining when at least one phase transition criterion of the second operational phase is satisfied by the measured streaming conditions, and transitioning the playback device to the first operational phase in which the first set of stream switching conditions are utilized in response to the determination.

33. The method of claim **18**, further comprising transitioning the playback device from the second operational phase to the first operational phase in response to a determination that the second set of stream switching conditions is satisfied by the measured streaming conditions such that a stream switch occurs involving the playback device requesting portions of encoded media from a stream of the plurality of alternative streams having a maximum bitrate that is lower than the maximum bitrate of the second one of the plurality of streams from which the playback device was requesting portions of the encoded media prior to the stream switch.

34. The method of claim **33**, further comprising suspending requests from the playback device for portions of encoded media from the stream following the stream switch until the amount of buffered media is less than a maximum buffer size that forms part of the first set of stream switching conditions.

35. The method of claim **33**, further comprising suspending requests from the playback device for portions of encoded media from the stream following the stream switch until the amount of buffered media measured in units of time is less than a maximum amount of time that forms part of the first set of stream switching conditions.

36. The method of claim **18**, further comprising determining when at least one phase transition criterion is satisfied, and transitioning the playback device to the previous operational phase in which the corresponding enumeration of the set of stream switching conditions are utilized in response to the determination.

37. The method of claim **18**, further comprising transitioning the playback device from an operational phase greater than the first to the previous operational phase in response to the corresponding enumeration of the set of stream switching conditions being satisfied such that a stream switch occurs involving the playback device requesting portions of encoded media from a stream having a maximum bitrate that is lower than the maximum bitrate of the stream from which the playback device was requesting portions of the encoded media prior to the stream switch.

18

38. The method of claim **37**, further comprising suspending requests from the playback device for portions of encoded media from the stream following the stream switch until the amount of buffered media is less than a maximum buffer size that forms part of the previous set of stream switching conditions.

39. The method of claim **37**, further comprising suspending requests from the playback device for portions of encoded media from the stream following the stream switch until the amount of buffered media measured in units of time is less than a maximum amount of time that forms part of the previous set of stream switching conditions.

40. A non-transitory machine readable medium containing processor instructions, where execution of the instructions by a processor causes the processor to perform a process comprising:

commencing streaming of the encoded media in a first operational phase utilizing a first set of stream switching conditions by requesting portions of the encoded media from a first one of the plurality of alternative streams encoded at a first maximum bitrate;

measuring streaming conditions for receiving the requested portions of the encoded media from a current one of the plurality of alternative streams encoded at a current maximum bitrate;

determining when the first set of stream switching conditions is satisfied in a first operational phase by the measured streaming conditions;

requesting portions of the encoded media from another one of the plurality of alternative streams encoded at a maximum bitrate that is different from the current maximum bitrate in response to a determination that the first set of stream switching conditions is satisfied;

determining when at least one phase transition criterion of the first operational phase is satisfied by the measured streaming conditions;

transitioning to a second operational phase utilizing a second set of stream switching conditions with respect to the current one of the plurality of alternative streams in response to a determination that the at least one phase transition criterion is satisfied;

determining when the second set of stream switching conditions is satisfied by the measured streaming conditions in the second operational phase; and

requesting portions of the encoded media from another one of the plurality of alternative streams encoded at a maximum bit rate that is different from the current maximum bitrate in response to the determination that second set of streaming conditions is satisfied.

41. The non-transitory machine readable medium of claim **40**, wherein the machine readable medium is non-volatile memory.

* * * * *

US010212486B2

(12) **United States Patent**
Chan et al.

(10) **Patent No.:** **US 10,212,486 B2**
(45) **Date of Patent:** **Feb. 19, 2019**

(54) **ELEMENTARY BITSTREAM CRYPTOGRAPHIC MATERIAL TRANSPORT SYSTEMS AND METHODS**

(71) Applicant: **DIVX, LLC**, San Diego, CA (US)

(72) Inventors: **Francis Yee-Dug Chan**, San Diego, CA (US); **Kourosh Soroushian**, San Diego, CA (US); **Andrew Jeffrey Wood**, San Diego, CA (US)

(73) Assignee: **DIVX, LLC**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/615,626**

(22) Filed: **Jun. 6, 2017**

(65) **Prior Publication Data**
US 2017/0280203 A1   Sep. 28, 2017

Related U.S. Application Data

(63) Continuation of application No. 14/839,783, filed on Aug. 28, 2015, now Pat. No. 9,706,259, which is a
(Continued)

(51) **Int. Cl.**
H04L 29/06 (2006.01)
H04N 21/6334 (2011.01)
(Continued)

(52) **U.S. Cl.**
CPC ... *H04N 21/63345* (2013.01); *H04L 63/0428* (2013.01); *H04L 65/607* (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H04L 63/0428
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,009,331 A   2/1977   Goldmark et al.
4,694,357 A   9/1987   Rahman et al.
(Continued)

FOREIGN PATENT DOCUMENTS

AU   2010203605 B2   5/2015
CN   1169229   12/1997
(Continued)

OTHER PUBLICATIONS

Taxan, A Vel LinkPlayer2 for Consumer, I-O Data USA—Products—Home Entertainment, printed May 4, 2007 from http://www.iodata.com/usa/products/products.php?cat=HNP&sc=AVEL&pId=AVLP2/DVDLA&ts=2&tsc, 1 pg.
(Continued)

Primary Examiner — Dao Q Ho
(74) *Attorney, Agent, or Firm* — KPPB LLP

(57) **ABSTRACT**

Systems and methods for providing multimedia content from one process or component to another process or component over an unsecured connection are provided. One embodiment includes obtaining the cryptographic information, extracting the at least partially encrypted video data from the container file to create an elementary bitstream, enciphering the cryptographic information, inserting the cryptographic information in the elementary bitstream, providing the elementary bitstream to a video decoder, extracting the cryptographic information from the elementary bitstream at the video decoder, deciphering the cryptographic information, decrypting the elementary bitstream with the cryptographic information and decoding the elementary bitstream for rendering on a display device using the video decoder.

25 Claims, 8 Drawing Sheets
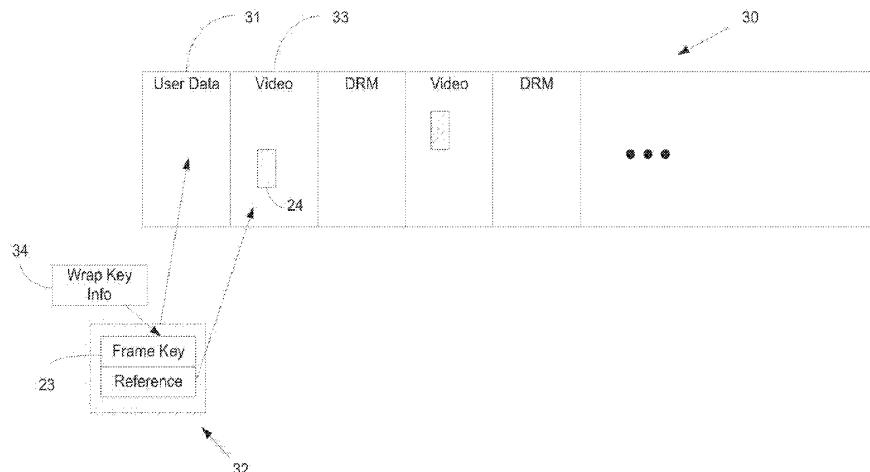
US 10,212,486 B2

Page 2

Related U.S. Application Data

continuation of application No. 14/306,146, filed on Jun. 16, 2014, now Pat. No. 9,124,773, which is a continuation of application No. 12/946,631, filed on Nov. 15, 2010, now Pat. No. 8,781,122.

(60) Provisional application No. 61/266,982, filed on Dec. 4, 2009.

(51) **Int. Cl.**

H04N 21/235	(2011.01)
H04N 21/236	(2011.01)
H04N 21/434	(2011.01)
H04N 21/4405	(2011.01)
H04N 7/167	(2011.01)
H04N 21/43	(2011.01)

(52) **U.S. Cl.**
CPC *H04N 7/1675* (2013.01); *H04N 21/2351* (2013.01); *H04N 21/23614* (2013.01); *H04N 21/4302* (2013.01); *H04N 21/4348* (2013.01); *H04N 21/4405* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,802,170 A	1/1989	Trottier
4,964,069 A	10/1990	Ely
5,119,474 A	6/1992	Beitel et al.
5,274,758 A	12/1993	Beitel et al.
5,361,332 A	11/1994	Yoshida et al.
5,396,497 A	3/1995	Veltman
5,404,436 A	4/1995	Hamilton
5,420,801 A	5/1995	Dockter et al.
5,420,974 A	5/1995	Morris et al.
5,471,576 A	11/1995	Yee
5,479,303 A	12/1995	Suzuki et al.
5,487,167 A	1/1996	Dinallo et al.
5,502,766 A	3/1996	Boebert et al.
5,509,070 A	4/1996	Schull
5,533,021 A	7/1996	Branstad et al.
5,537,408 A	7/1996	Branstad et al.
5,539,908 A	7/1996	Chen et al.
5,541,662 A	7/1996	Adams et al.
5,583,652 A	12/1996	Ware
5,589,993 A	12/1996	Naimpally et al.
5,621,794 A	4/1997	Matsuda et al.
5,627,936 A	5/1997	Prasad
5,633,472 A	5/1997	DeWitt et al.
5,642,171 A	6/1997	Baumgartner et al.
5,655,117 A	8/1997	Goldberg et al.
5,664,044 A	9/1997	Ware
5,675,382 A	10/1997	Bauchspies
5,675,511 A	10/1997	Prasad et al.
5,684,542 A	11/1997	Tsukagoshi
5,715,403 A	2/1998	Stefik
5,717,816 A	2/1998	Boyce et al.
5,719,786 A	2/1998	Nelson et al.
5,745,643 A	4/1998	Mishina
5,751,280 A	5/1998	Abbott
5,754,648 A	5/1998	Ryan et al.
5,763,800 A	6/1998	Rossum et al.
5,765,164 A	6/1998	Prasad et al.
5,794,018 A	8/1998	Vrvilo et al.
5,805,700 A	9/1998	Nardone et al.
5,822,524 A	10/1998	Chen et al.
5,828,370 A	10/1998	Moeller et al.
5,841,432 A	11/1998	Carmel et al.
5,844,575 A	12/1998	Reid
5,848,217 A	12/1998	Tsukagoshi et al.
5,867,625 A	2/1999	McLaren
5,887,110 A	3/1999	Sakamoto et al.
5,892,900 A	4/1999	Ginter et al.
5,903,261 A	5/1999	Walsh et al.
5,907,597 A	5/1999	Mark
5,946,446 A	8/1999	Yanagihara
5,956,729 A	9/1999	Goetz et al.
5,959,690 A	9/1999	Toebes, VIII et al.
5,970,147 A	10/1999	Davis
5,999,812 A	12/1999	Himsworth
6,031,622 A	2/2000	Ristow et al.
6,038,257 A	3/2000	Brusewitz et al.
6,044,469 A	3/2000	Horstmann
6,046,778 A	4/2000	Nonomura et al.
6,047,100 A	4/2000	McLaren
6,058,240 A	5/2000	McLaren
6,064,794 A	5/2000	McLaren et al.
6,065,050 A	5/2000	DeMoney
6,018,611 A	6/2000	Nogami et al.
6,079,566 A	6/2000	Eleftheriadis et al.
6,097,877 A	8/2000	Katayama et al.
6,141,754 A	10/2000	Choy
6,155,840 A	12/2000	Sallette
6,169,242 B1	1/2001	Fay et al.
6,175,921 B1	1/2001	Rosen
6,195,388 B1	2/2001	Choi et al.
6,204,883 B1	3/2001	Tsukagoshi
6,222,981 B1	4/2001	Rijckaert
6,282,653 B1	8/2001	Berstis et al.
6,289,450 B1	9/2001	Pensak et al.
6,292,621 B1	9/2001	Tanaka et al.
6,308,005 B1	10/2001	Ando et al.
6,330,286 B1	12/2001	Lyons et al.
6,374,144 B1	4/2002	Viviani et al.
6,389,218 B2	5/2002	Gordon et al.
6,389,473 B1	5/2002	Carmel et al.
6,395,969 B1	5/2002	Fuhrer
6,397,230 B1	5/2002	Carmel et al.
6,418,270 B1	7/2002	Steenhof et al.
6,449,719 B1	9/2002	Baker
6,466,671 B1	10/2002	Maillard et al.
6,466,733 B1	10/2002	Kim
6,510,513 B1	1/2003	Danieli
6,510,554 B1	1/2003	Gordon et al.
6,621,979 B1	9/2003	Eerenberg et al.
6,625,320 B1	9/2003	Ghanbari
6,658,056 B1	12/2003	Duruöz et al.
6,665,835 B1	12/2003	Gutfreund et al.
6,671,408 B1	12/2003	Kaku
6,697,568 B1	2/2004	Kaku
6,725,281 B1	4/2004	Zintel et al.
6,771,703 B1	8/2004	Oguz et al.
6,807,306 B1	10/2004	Girgensohn et al.
6,810,031 B1	10/2004	Hegde et al.
6,810,389 B1	10/2004	Meyer
6,819,394 B1	11/2004	Nomura et al.
6,850,252 B1	2/2005	Hoffberg
6,856,997 B2	2/2005	Lee et al.
6,859,496 B1	2/2005	Boroczky et al.
6,917,652 B2	7/2005	Lyu
6,931,531 B1	8/2005	Takahashi
6,944,621 B1	9/2005	Collart
6,944,629 B1	9/2005	Shioi et al.
6,956,901 B2	10/2005	Boroczky et al.
6,965,724 B1	11/2005	Boccon-Gibod et al.
6,965,993 B2	11/2005	Baker
6,985,588 B1	1/2006	Glick et al.
6,988,144 B1	1/2006	Luken et al.
7,007,170 B2	2/2006	Morten
7,023,924 B1	4/2006	Keller et al.
7,043,473 B1	5/2006	Rassool et al.
7,103,906 B1	9/2006	Katz et al.
7,127,155 B2	10/2006	Ando et al.
7,150,045 B2	12/2006	Koelle et al.
7,151,832 B1	12/2006	Fetkovich et al.
7,151,833 B2	12/2006	Candelore et al.
7,165,175 B1	1/2007	Kollmyer et al.
7,185,363 B1	2/2007	Narin et al.
7,197,234 B1	3/2007	Chatterton
7,206,940 B2	4/2007	Evans et al.
7,209,892 B1	4/2007	Galuten et al.
7,231,132 B1	6/2007	Davenport
7,237,061 B1	6/2007	Boic

Appx21

US 10,212,486 B2

Page 3

(56)   **References Cited**

U.S. PATENT DOCUMENTS

7,242,772 B1	7/2007	Tehranchi
7,243,346 B1	7/2007	Seth et al.
7,295,673 B2	11/2007	Grab et al.
7,328,345 B2	2/2008	Morten et al.
7,330,875 B1	2/2008	Parasnis et al.
7,340,528 B2	3/2008	Noblecourt et al.
7,349,886 B2	3/2008	Morten et al.
7,356,143 B2	4/2008	Morten
7,356,245 B2	4/2008	Belknap et al.
7,366,788 B2	4/2008	Jones et al.
7,376,831 B2	5/2008	Kollmyer et al.
7,406,174 B2	7/2008	Palmer
7,421,411 B2	9/2008	Kontio et al.
7,454,780 B2	11/2008	Katsube et al.
7,457,359 B2	11/2008	Mabey et al.
7,472,280 B2	12/2008	Giobbi
7,478,325 B2	1/2009	Foehr
7,484,103 B2	1/2009	Woo et al.
7,493,018 B2	2/2009	Kim
7,499,938 B2	3/2009	Collart
7,515,710 B2	4/2009	Russell et al.
7,526,450 B2	4/2009	Hughes et al.
7,594,271 B2	9/2009	Zhuk et al.
7,610,365 B1	10/2009	Kraft et al.
7,640,435 B2	12/2009	Morten
7,689,510 B2	3/2010	Lamkin et al.
7,720,352 B2	5/2010	Belknap et al.
7,747,853 B2	6/2010	Candelore et al.
7,761,892 B2	7/2010	Ellis et al.
7,779,097 B2	8/2010	Lamkin et al.
7,788,271 B2	8/2010	Soma et al.
7,817,608 B2	10/2010	Rassool et al.
7,869,691 B2	1/2011	Kelly et al.
7,882,034 B2	2/2011	Hug et al.
7,949,703 B2	5/2011	Matsuzaki et al.
7,962,942 B1	6/2011	Craner
7,974,714 B2	7/2011	Hoffberg
7,991,156 B1	8/2011	Miller
8,023,562 B2	9/2011	Zheludkov et al.
8,046,453 B2	10/2011	Olaiya
8,054,880 B2	11/2011	Yu et al.
8,065,708 B1	11/2011	Smyth et al.
8,069,260 B2	11/2011	Speicher et al.
8,082,442 B2	12/2011	Keljo et al.
8,195,714 B2	6/2012	Mckibben et al.
8,201,264 B2	6/2012	Grab et al.
8,225,061 B2	7/2012	Greenebaum
8,233,768 B2	7/2012	Soroushian et al.
8,245,124 B1	8/2012	Gupta
8,249,168 B2	8/2012	Graves
8,261,356 B2	9/2012	Choi et al.
8,265,168 B1	9/2012	Masterson et al.
8,270,473 B2	9/2012	Chen et al.
8,270,819 B2	9/2012	Vannier
8,275,871 B2	9/2012	Ram et al.
8,289,338 B2	10/2012	Priyadarshi et al.
8,291,460 B1	10/2012	Peacock
8,296,434 B1	10/2012	Miller et al.
8,311,111 B2	11/2012	Xu
8,311,115 B2	11/2012	Gu et al.
8,321,556 B1	11/2012	Chatterjee et al.
8,341,715 B2	12/2012	Sherkin et al.
8,386,621 B2	2/2013	Park
8,396,114 B2	3/2013	Gu et al.
8,401,900 B2	3/2013	Cansler et al.
8,407,753 B2	3/2013	Kuo
8,412,841 B1	4/2013	Swaminathan et al.
8,423,889 B1	4/2013	Zagorie et al.
8,452,110 B2	5/2013	Shoham et al.
8,456,380 B2	6/2013	Pagan
8,472,792 B2	6/2013	Butt et al.
8,473,630 B1	6/2013	Galligan et al.
8,510,303 B2	8/2013	Soroushian et al.
8,510,404 B2	8/2013	Carmel et al.
8,515,265 B2	8/2013	Kwon et al.
8,516,529 B2	8/2013	Lajoie et al.
8,527,645 B1	9/2013	Proffit et al.
8,595,378 B1	11/2013	Cohn
8,606,069 B2	12/2013	Okubo et al.
8,640,166 B1	1/2014	Craner et al.
8,649,669 B2	2/2014	Braness et al.
8,656,183 B2	2/2014	Russell et al.
8,677,428 B2	3/2014	Lewis et al.
8,681,866 B1	3/2014	Jia
8,689,267 B2	4/2014	Hunt
8,726,264 B1	5/2014	Allen et al.
RE45,052 E	7/2014	Li
8,767,825 B1	7/2014	Wang et al.
8,774,609 B2	7/2014	Drake et al.
8,781,122 B2	7/2014	Chan et al.
8,805,109 B2	8/2014	Shoham et al.
8,806,188 B2	8/2014	Braness et al.
8,832,434 B2	9/2014	Apostolopoulos et al.
8,843,586 B2	9/2014	Pantos et al.
8,856,218 B1	10/2014	Inskip
8,908,984 B2	12/2014	Shoham et al.
8,909,922 B2	12/2014	Kiefer et al.
8,914,534 B2	12/2014	Braness et al.
8,914,836 B2	12/2014	Shivadas et al.
8,918,535 B2	12/2014	Ma et al.
8,918,636 B2	12/2014	Kiefer et al.
8,918,908 B2	12/2014	Ziskind et al.
8,948,249 B2	2/2015	Sun et al.
8,997,161 B2	3/2015	Priyadarshi et al.
8,997,254 B2	3/2015	Amidei et al.
9,014,471 B2	4/2015	Shoham et al.
9,025,659 B2	5/2015	Soroushian et al.
9,042,670 B2	5/2015	Carmel et al.
9,060,207 B2	6/2015	Scherkus et al.
9,094,737 B2	7/2015	Shivadas et al.
9,098,335 B2	8/2015	Muthiah et al.
9,124,773 B2	9/2015	Chan et al.
9,125,073 B2	9/2015	Oyman et al.
9,184,920 B2	11/2015	Grab et al.
9,191,457 B2	11/2015	Van der Schaar
9,197,685 B2	11/2015	Soroushian
9,203,816 B2	12/2015	Brueck et al.
9,210,481 B2	12/2015	Braness et al.
9,215,466 B2	12/2015	Zhai et al.
9,247,311 B2	1/2016	Kiefer
9,247,312 B2	1/2016	Braness et al.
9,247,317 B2	1/2016	Shivadas et al.
9,253,178 B2	2/2016	Blom et al.
9,264,475 B2	2/2016	Shivadas et al.
9,294,531 B2	3/2016	Zhang et al.
9,313,510 B2	4/2016	Shivadas et al.
9,343,112 B2	5/2016	Amidei et al.
9,344,517 B2	5/2016	Shivadas et al.
9,344,721 B2	5/2016	Dikvall
9,479,805 B2	10/2016	Rothschild et al.
9,485,546 B2	11/2016	Chen et al.
9,571,827 B2	2/2017	Su et al.
9,584,557 B2	2/2017	Panje et al.
9,584,847 B2	2/2017	Ma et al.
9,621,522 B2	4/2017	Kiefer et al.
9,706,259 B2	7/2017	Chan et al.
9,712,890 B2	7/2017	Shivadas et al.
9,798,863 B2	10/2017	Grab et al.
9,813,740 B2	11/2017	Panje et al.
9,866,878 B2	1/2018	van der Schaar et al.
9,883,204 B2	1/2018	Braness et al.
9,906,785 B2	2/2018	Naletov et al.
9,967,189 B2	5/2018	Patel et al.
9,967,305 B2	5/2018	Braness
2001/0030710 A1	10/2001	Werner
2001/0036355 A1	11/2001	Kelly et al.
2001/0046299 A1	11/2001	Wasilewski et al.
2001/0053222 A1*	12/2001	Wakao H04N 21/234318
		380/43
2002/0026560 A1	2/2002	Jordan et al.
2002/0034252 A1	3/2002	Owen et al.
2002/0051494 A1	5/2002	Yamaguchi et al.
2002/0057898 A1	5/2002	Normile
2002/0062313 A1	5/2002	Lee et al.

US 10,212,486 B2

Page 4

(56)   **References Cited**

U.S. PATENT DOCUMENTS

2002/0076112 A1	6/2002	Devara
2002/0087569 A1	7/2002	Fischer et al.
2002/0091665 A1	7/2002	Van Beek et al.
2002/0093571 A1	7/2002	Hyodo
2002/0110193 A1	8/2002	Yoo et al.
2002/0116481 A1	8/2002	Lee
2002/0118953 A1	8/2002	Kim
2002/0120934 A1	8/2002	Abrahams et al.
2002/0136298 A1	9/2002	Anantharamu et al.
2002/0143413 A1	10/2002	Fay et al.
2002/0143547 A1	10/2002	Fay et al.
2002/0147980 A1	10/2002	Satoda
2002/0159598 A1	10/2002	Rubinstein et al.
2002/0161462 A1	10/2002	Fay et al.
2002/0180929 A1	12/2002	Tseng et al.
2002/0184159 A1	12/2002	Tayadon et al.
2002/0184515 A1	12/2002	Oho et al.
2002/0191112 A1	12/2002	Akiyoshi et al.
2002/0191959 A1	12/2002	Lin et al.
2002/0191960 A1	12/2002	Fujinami et al.
2003/0001964 A1	1/2003	Masukura et al.
2003/0002578 A1	1/2003	Tsukagoshi et al.
2003/0005442 A1	1/2003	Brodersen et al.
2003/0021296 A1	1/2003	Wee et al.
2003/0031178 A1	2/2003	Haeri
2003/0035488 A1	2/2003	Barrau
2003/0035545 A1	2/2003	Jiang
2003/0035546 A1	2/2003	Jiang et al.
2003/0041257 A1*	2/2003	Wee H04N 7/167
		713/193
2003/0061305 A1	3/2003	Copley et al.
2003/0061369 A1	3/2003	Aksu et al.
2003/0065777 A1	4/2003	Mattila et al.
2003/0078930 A1	4/2003	Surcouf et al.
2003/0093799 A1	5/2003	Kauffman et al.
2003/0123855 A1	7/2003	Okada et al.
2003/0128296 A1	7/2003	Lee
2003/0133506 A1	7/2003	Haneda
2003/0152370 A1	8/2003	Otomo et al.
2003/0163824 A1	8/2003	Gordon et al.
2003/0165328 A1	9/2003	Grecia
2003/0174844 A1	9/2003	Candelore
2003/0185302 A1	10/2003	Abrams
2003/0185542 A1	10/2003	McVeigh et al.
2003/0206558 A1	11/2003	Parkkinen et al.
2003/0216922 A1	11/2003	Gonzales et al.
2003/0229900 A1	12/2003	Reisman
2003/0231863 A1	12/2003	Eerenberg et al.
2003/0231867 A1	12/2003	Gates
2003/0233464 A1	12/2003	Walpole et al.
2003/0236836 A1	12/2003	Borthwick
2003/0236907 A1	12/2003	Stewart et al.
2004/0006701 A1	1/2004	Kresina
2004/0021684 A1	2/2004	Millner
2004/0024688 A1	2/2004	Bi et al.
2004/0025180 A1	2/2004	Begeja et al.
2004/0031058 A1	2/2004	Reisman
2004/0039916 A1	2/2004	Aldis et al.
2004/0047614 A1	3/2004	Green
2004/0052501 A1	3/2004	Tam
2004/0071453 A1	4/2004	Valderas
2004/0081333 A1*	4/2004	Grab H04K 1/00
		382/100
2004/0081434 A1	4/2004	Jung et al.
2004/0084035 A1	5/2004	Newton
2004/0093618 A1	5/2004	Baldwin et al.
2004/0105549 A1	6/2004	Suzuki et al.
2004/0114687 A1	6/2004	Ferris et al.
2004/0117347 A1	6/2004	Seo et al.
2004/0136698 A1	7/2004	Mock
2004/0139335 A1	7/2004	Diamand et al.
2004/0143760 A1	7/2004	Alkove et al.
2004/0146276 A1	7/2004	Ogawa
2004/0158878 A1	8/2004	Ratnakar et al.
2004/0184534 A1	9/2004	Wang
2004/0184616 A1	9/2004	Morten et al.
2004/0202320 A1	10/2004	Amini et al.
2004/0217971 A1	11/2004	Kim
2004/0255115 A1	12/2004	DeMello et al.
2004/0255236 A1	12/2004	Collart
2005/0004875 A1	1/2005	Kontio et al.
2005/0005025 A1	1/2005	Harville et al.
2005/0015797 A1	1/2005	Noblecourt et al.
2005/0038826 A1	2/2005	Bae et al.
2005/0055399 A1	3/2005	Savchuk
2005/0071280 A1	3/2005	Irwin et al.
2005/0108320 A1	5/2005	Lord et al.
2005/0114534 A1	5/2005	Lee
2005/0114896 A1	5/2005	Hug
2005/0132208 A1	6/2005	Hug et al.
2005/0149450 A1	7/2005	Stefik et al.
2005/0180641 A1	8/2005	Clark
2005/0183120 A1	8/2005	Jain et al.
2005/0193070 A1	9/2005	Brown et al.
2005/0193322 A1	9/2005	Lamkin et al.
2005/0196147 A1	9/2005	Seo et al.
2005/0204289 A1	9/2005	Mohammed et al.
2005/0207442 A1	9/2005	van Zoest et al.
2005/0207578 A1	9/2005	Matsuyama et al.
2005/0254508 A1	11/2005	Aksu et al.
2005/0273695 A1	12/2005	Schnurr
2005/0275656 A1	12/2005	Corbin et al.
2006/0015580 A1	1/2006	Gabriel et al.
2006/0026294 A1	2/2006	Virdi et al.
2006/0026302 A1	2/2006	Bennett et al.
2006/0036549 A1	2/2006	Wu
2006/0037057 A1	2/2006	Xu
2006/0052095 A1	3/2006	Vazvan
2006/0053080 A1	3/2006	Edmonson et al.
2006/0064605 A1	3/2006	Giobbi
2006/0078301 A1	4/2006	Ikeda et al.
2006/0093320 A1	5/2006	Hallberg et al.
2006/0120378 A1	6/2006	Usuki et al.
2006/0129909 A1	6/2006	Butt et al.
2006/0165233 A1	7/2006	Nonaka et al.
2006/0168639 A1	7/2006	Gan et al.
2006/0173887 A1	8/2006	Breitfeld et al.
2006/0179239 A1	8/2006	Fluhr
2006/0181965 A1	8/2006	Collart
2006/0235880 A1	10/2006	Qian
2006/0245727 A1	11/2006	Nakano et al.
2006/0259588 A1	11/2006	Lerman et al.
2006/0263056 A1	11/2006	Lin et al.
2006/0267986 A1	11/2006	Bae
2006/0274835 A1	12/2006	Hamilton et al.
2006/0294164 A1	12/2006	Armangau et al.
2007/0005333 A1	1/2007	Setiohardjo et al.
2007/0031110 A1	2/2007	Rijckaert
2007/0033419 A1	2/2007	Kocher et al.
2007/0044010 A1	2/2007	Sull et al.
2007/0047901 A1	3/2007	Ando et al.
2007/0053513 A1	3/2007	Hoffberg
2007/0058928 A1	3/2007	Naito et al.
2007/0083617 A1	4/2007	Chakrabarti et al.
2007/0086528 A1	4/2007	Mauchly et al.
2007/0100757 A1	5/2007	Rhoads
2007/0133603 A1	6/2007	Weaver
2007/0136817 A1	6/2007	Nguyen
2007/0140647 A1	6/2007	Kusunoki et al.
2007/0154165 A1	7/2007	Hemmeryckz-Deleersnijder et al.
2007/0168541 A1	7/2007	Gupta et al.
2007/0168542 A1	7/2007	Gupta et al.
2007/0178933 A1	8/2007	Nelson
2007/0180125 A1	8/2007	Knowles et al.
2007/0185982 A1	8/2007	Nakanowatari et al.
2007/0192810 A1	8/2007	Pritchett et al.
2007/0217339 A1	9/2007	Zhao
2007/0217759 A1	9/2007	Dodd
2007/0234391 A1	10/2007	Hunter et al.
2007/0239839 A1	10/2007	Buday et al.
2007/0255940 A1*	11/2007	Ueno H04K 1/00
		713/150
2007/0271317 A1	11/2007	Carmel et al.
2007/0271385 A1	11/2007	Davis et al.

Appx23

US 10,212,486 B2

Page 5

(56)   **References Cited**

U.S. PATENT DOCUMENTS

2007/0274679 A1	11/2007	Yahata et al.
2007/0277219 A1	11/2007	Toebes et al.
2007/0277234 A1	11/2007	Bessonov et al.
2007/0280298 A1	12/2007	Hearn et al.
2007/0288745 A1*	12/2007	Kwan H04L 9/0822
		713/155
2007/0292107 A1	12/2007	Yahata et al.
2007/0297422 A1	12/2007	Matsuo et al.
2008/0005175 A1	1/2008	Bourke et al.
2008/0008455 A1	1/2008	De Lange et al.
2008/0043832 A1	2/2008	Barkley et al.
2008/0046718 A1	2/2008	Grab
2008/0066099 A1	3/2008	Brodersen et al.
2008/0066181 A1	3/2008	Haveson et al.
2008/0077592 A1	3/2008	Brodie et al.
2008/0086456 A1	4/2008	Rasanen et al.
2008/0086747 A1	4/2008	Rasanen et al.
2008/0101466 A1	5/2008	Swenson et al.
2008/0104633 A1	5/2008	Noblecourt et al.
2008/0120330 A1	5/2008	Reed et al.
2008/0120342 A1	5/2008	Reed et al.
2008/0120389 A1	5/2008	Bassali et al.
2008/0126248 A1	5/2008	Lee et al.
2008/0137541 A1	6/2008	Agarwal
2008/0137736 A1	6/2008	Richardson
2008/0151817 A1	6/2008	Fitchett
2008/0172441 A1	7/2008	Speicher et al.
2008/0187283 A1	8/2008	Takahashi
2008/0192818 A1	8/2008	DiPietro et al.
2008/0195664 A1	8/2008	Mharajh et al.
2008/0195744 A1	8/2008	Bwra et al.
2008/0201705 A1	8/2008	Wookey
2008/0205860 A1	8/2008	Hltman
2008/0209534 A1	8/2008	Keronen et al.
2008/0240144 A1	10/2008	Krse et al.
2008/0256105 A1	10/2008	Nogwa et al.
2008/0263354 A1	10/2008	Beuque et al.
2008/0279535 A1	11/2008	Haque et al.
2008/0294453 A1	11/2008	Baid-Smith et al.
2008/0298358 A1	12/2008	John et al.
2008/0310454 A1	12/2008	Belwood et al.
2008/0310496 A1	12/2008	Fan
2009/0031220 A1	1/2009	Tranchnt et al.
2009/0037959 A1	2/2009	Suh et al.
2009/0048852 A1	2/2009	Burns et al.
2009/0055546 A1	2/2009	Jung et al.
2009/0060452 A1	3/2009	Chaudhri
2009/0064341 A1	3/2009	Hartung et al.
2009/0066839 A1	3/2009	Jung et al.
2009/0097644 A1*	4/2009	Haruki G11B 20/00086
		380/200
2009/0132599 A1	5/2009	Soroushian et al.
2009/0132721 A1	5/2009	Soroushian et al.
2009/0132824 A1	5/2009	Terada et al.
2009/0136216 A1	5/2009	Soroushian et al.
2009/0150557 A1	6/2009	Wormley et al.
2009/0165148 A1	6/2009	Frey et al.
2009/0168795 A1	7/2009	Segel et al.
2009/0169181 A1	7/2009	Priyadarshi et al.
2009/0172201 A1	7/2009	Carmel et al.
2009/0178090 A1	7/2009	Oztaskent
2009/0196139 A1	8/2009	Bates et al.
2009/0201988 A1	8/2009	Gazier et al.
2009/0217317 A1	8/2009	White et al.
2009/0226148 A1	9/2009	Nesvadba et al.
2009/0228395 A1	9/2009	Wegner et al.
2009/0265737 A1	10/2009	Issa et al.
2009/0276636 A1	11/2009	Grab et al.
2009/0290706 A1	11/2009	Amini et al.
2009/0290708 A1	11/2009	Schneider et al.
2009/0293116 A1	11/2009	DeMello
2009/0303241 A1	12/2009	Priyadarshi et al.
2009/0307258 A1	12/2009	Priyadarshi et al.
2009/0307267 A1	12/2009	Chen et al.
2009/0310819 A1	12/2009	Hatano

2009/0310933 A1	12/2009	Lee
2009/0313544 A1	12/2009	Wood et al.
2009/0313564 A1	12/2009	Rottler et al.
2009/0316783 A1	12/2009	Au et al.
2009/0328124 A1	12/2009	Khouzam et al.
2009/0328228 A1	12/2009	Schnell
2010/0040351 A1	2/2010	Toma et al.
2010/0057928 A1	3/2010	Kapoor et al.
2010/0058405 A1	3/2010	Ramakrishnan et al.
2010/0074324 A1	3/2010	Qian et al.
2010/0074333 A1	3/2010	Au et al.
2010/0083322 A1	4/2010	Rouse
2010/0094969 A1	4/2010	Zuckerman et al.
2010/0095121 A1	4/2010	Shetty et al.
2010/0106968 A1	4/2010	Mori et al.
2010/0107260 A1	4/2010	Orrell et al.
2010/0111192 A1	5/2010	Graves
2010/0138903 A1	6/2010	Medvinsky
2010/0142917 A1	6/2010	Isaji
2010/0158109 A1	6/2010	Dahlby et al.
2010/0161825 A1	6/2010	Ronca et al.
2010/0166060 A1	7/2010	Ezure et al.
2010/0186092 A1	7/2010	Takechi et al.
2010/0189183 A1	7/2010	Gu et al.
2010/0218208 A1	8/2010	Holden
2010/0228795 A1	9/2010	Hahn
2010/0235472 A1	9/2010	Sood et al.
2010/0250532 A1	9/2010	Soroushian et al.
2010/0290761 A1	11/2010	Drake et al.
2010/0299522 A1	11/2010	Khambete et al.
2010/0306249 A1	12/2010	Hill et al.
2010/0313225 A1	12/2010	Cholas et al.
2010/0313226 A1	12/2010	Cholas et al.
2010/0319014 A1	12/2010	Lockett et al.
2010/0319017 A1	12/2010	Cook
2010/0332595 A1	12/2010	Fullagar et al.
2011/0002381 A1	1/2011	Yang et al.
2011/0016225 A1	1/2011	Park
2011/0047209 A1	2/2011	Lindholm et al.
2011/0055585 A1	3/2011	Lee
2011/0060808 A1	3/2011	Martin et al.
2011/0066673 A1	3/2011	Outlaw
2011/0067057 A1	3/2011	Karaoguz et al.
2011/0078440 A1	3/2011	Feng et al.
2011/0080940 A1	4/2011	Bocharov
2011/0082924 A1	4/2011	Gopalakrishnan
2011/0096828 A1	4/2011	Chen et al.
2011/0107379 A1	5/2011	Lajoie et al.
2011/0116772 A1	5/2011	Kwon et al.
2011/0126191 A1	5/2011	Hughes et al.
2011/0129011 A1	6/2011	Cilli et al.
2011/0135090 A1	6/2011	Chan et al.
2011/0138018 A1	6/2011	Raveendran et al.
2011/0142415 A1	6/2011	Rhyu
2011/0145726 A1	6/2011	Wei et al.
2011/0149753 A1	6/2011	Bapst et al.
2011/0150100 A1	6/2011	Abadir
2011/0153785 A1	6/2011	Minborg et al.
2011/0153835 A1	6/2011	Rimac et al.
2011/0184738 A1	7/2011	Kalisky et al.
2011/0191439 A1	8/2011	Dazzi et al.
2011/0191803 A1	8/2011	Baldwin et al.
2011/0197237 A1	8/2011	Turner
2011/0197267 A1	8/2011	Gravel et al.
2011/0213827 A1	9/2011	Kaspar et al.
2011/0222786 A1	9/2011	Carmel et al.
2011/0225302 A1	9/2011	Park et al.
2011/0225315 A1	9/2011	Wexler et al.
2011/0225417 A1	9/2011	Maharajh et al.
2011/0239078 A1	9/2011	Luby et al.
2011/0246657 A1	10/2011	Glow
2011/0246659 A1	10/2011	Bouazizi
2011/0252118 A1	10/2011	Pantos et al.
2011/0264530 A1	10/2011	Santangelo et al.
2011/0268178 A1	11/2011	Park et al.
2011/0276695 A1	11/2011	Maldaner et al.
2011/0283012 A1	11/2011	Melnyk
2011/0291723 A1	12/2011	Hashimoto
2011/0302319 A1	12/2011	Ha et al.

Appx24

US 10,212,486 B2

Page 6

(56)   **References Cited**

U.S. PATENT DOCUMENTS

2011/0305273 A1	12/2011	He et al.
2011/0314176 A1	12/2011	Frojdh et al.
2011/0314500 A1	12/2011	Gordon
2012/0005368 A1	1/2012	Knittle et al.
2012/0017282 A1	1/2012	Kang et al.
2012/0023251 A1	1/2012	Pyle et al.
2012/0036365 A1	2/2012	Kyslov et al.
2012/0036544 A1	2/2012	Chen et al.
2012/0066360 A1	3/2012	Ghosh
2012/0093214 A1	4/2012	Urbach
2012/0114302 A1	5/2012	Randall et al.
2012/0124191 A1	5/2012	Lyon
2012/0137336 A1	5/2012	Applegate et al.
2012/0144117 A1	6/2012	Weare et al.
2012/0144445 A1	6/2012	Bonta et al.
2012/0166633 A1	6/2012	Baumback et al.
2012/0170642 A1	7/2012	Braness et al.
2012/0170643 A1	7/2012	Soroushian et al.
2012/0170906 A1	7/2012	Soroushian et al.
2012/0170915 A1	7/2012	Braness et al.
2012/0173751 A1	7/2012	Braness et al.
2012/0177101 A1	7/2012	van der Schaar
2012/0179834 A1	7/2012	van der Schaar et al.
2012/0201475 A1	8/2012	Carmel et al.
2012/0201476 A1	8/2012	Carmel et al.
2012/0233345 A1	9/2012	Hannuksela
2012/0240176 A1	9/2012	Ma et al.
2012/0254455 A1	10/2012	Adimatyam et al.
2012/0260277 A1	10/2012	Kosciewicz
2012/0263434 A1	10/2012	Wainner et al.
2012/0265562 A1	10/2012	Daouk et al.
2012/0278496 A1	11/2012	Hsu
2012/0289147 A1	11/2012	Raleigh et al.
2012/0294355 A1	11/2012	Holcomb et al.
2012/0297039 A1	11/2012	Acuna et al.
2012/0307883 A1	12/2012	Graves
2012/0311094 A1	12/2012	Biderman et al.
2012/0314778 A1	12/2012	Salustri et al.
2012/0317235 A1	12/2012	Nguyen et al.
2013/0007223 A1	1/2013	Luby et al.
2013/0013730 A1	1/2013	Li et al.
2013/0019107 A1	1/2013	Grab et al.
2013/0019273 A1	1/2013	Ma et al.
2013/0041808 A1	2/2013	Pham et al.
2013/0044821 A1	2/2013	Braness et al.
2013/0046849 A1	2/2013	Wolf
2013/0046902 A1	2/2013	Villegas Nuñez et al.
2013/0051554 A1	2/2013	Braness et al.
2013/0054958 A1	2/2013	Braness et al.
2013/0055084 A1	2/2013	Soroushian et al.
2013/0058480 A1	3/2013	Ziskind et al.
2013/0061040 A1	3/2013	Kiefer et al.
2013/0061045 A1	3/2013	Kiefer et al.
2013/0064466 A1	3/2013	Carmel et al.
2013/0066838 A1	3/2013	Singla et al.
2013/0094565 A1	4/2013	Yang et al.
2013/0097309 A1	4/2013	Ma et al.
2013/0114944 A1	5/2013	Soroushian et al.
2013/0124859 A1	5/2013	Pestoni et al.
2013/0128962 A1	5/2013	Rajagopalan et al.
2013/0152767 A1	6/2013	Katz et al.
2013/0166580 A1	6/2013	Maharajh
2013/0166765 A1	6/2013	Kaufman
2013/0166906 A1	6/2013	Swaminathan et al.
2013/0170561 A1	7/2013	Hannuksela
2013/0170764 A1	7/2013	Carmel et al.
2013/0173513 A1	7/2013	Chu et al.
2013/0179199 A1	7/2013	Ziskind et al.
2013/0179992 A1	7/2013	Ziskind et al.
2013/0182952 A1	7/2013	Carmel et al.
2013/0196292 A1	8/2013	Brennen et al.
2013/0212228 A1	8/2013	Butler
2013/0223812 A1	8/2013	Rossi
2013/0226578 A1	8/2013	Bolton et al.
2013/0226635 A1	8/2013	Fisher

2013/0227081 A1	8/2013	Luby et al.
2013/0227122 A1	8/2013	Gao
2013/0301424 A1	11/2013	Kotecha et al.
2013/0311670 A1	11/2013	Tarbox et al.
2013/0329781 A1	12/2013	Su et al.
2014/0003516 A1	1/2014	Soroushian
2014/0019593 A1	1/2014	Reznik et al.
2014/0037620 A1	2/2014	Ferree et al.
2014/0052823 A1	2/2014	Gavade et al.
2014/0059156 A1	2/2014	Freeman, II et al.
2014/0096171 A1	4/2014	Shivadas et al.
2014/0101722 A1	4/2014	Moore
2014/0115650 A1	4/2014	Zhang et al.
2014/0119432 A1	5/2014	Wang et al.
2014/0140396 A1	5/2014	Wang et al.
2014/0140417 A1	5/2014	Shaffer et al.
2014/0143301 A1	5/2014	Watson et al.
2014/0143431 A1	5/2014	Watson et al.
2014/0143440 A1	5/2014	Ramamurthy et al.
2014/0177734 A1	6/2014	Carmel et al.
2014/0189065 A1	7/2014	van der Schaar et al.
2014/0201382 A1	7/2014	Shivadas et al.
2014/0211840 A1	7/2014	Butt et al.
2014/0211859 A1	7/2014	Carmel et al.
2014/0241420 A1	8/2014	Orton-jay et al.
2014/0241421 A1	8/2014	Orton-jay et al.
2014/0247869 A1	9/2014	Su
2014/0250473 A1	9/2014	Braness et al.
2014/0258714 A1	9/2014	Grab
2014/0269927 A1	9/2014	Naletov et al.
2014/0269936 A1	9/2014	Shivadas et al.
2014/0280763 A1	9/2014	Grab et al.
2014/0297804 A1	10/2014	Shivadas et al.
2014/0297881 A1	10/2014	Shivadas et al.
2014/0355668 A1	12/2014	Shoham et al.
2014/0359678 A1	12/2014	Shivadas et al.
2014/0359679 A1	12/2014	Shivadas et al.
2014/0359680 A1	12/2014	Shivadas et al.
2014/0376720 A1	12/2014	Chan et al.
2015/0006662 A1	1/2015	Braness
2015/0026677 A1	1/2015	Stevens et al.
2015/0049957 A1	2/2015	Shoham et al.
2015/0063693 A1	3/2015	Carmel et al.
2015/0067715 A1	3/2015	Koat et al.
2015/0104153 A1	4/2015	Braness et al.
2015/0117836 A1	4/2015	Amidei et al.
2015/0117837 A1	4/2015	Amidei et al.
2015/0139419 A1	5/2015	Kiefer et al.
2015/0188758 A1	7/2015	Amidei et al.
2015/0188842 A1	7/2015	Amidei et al.
2015/0188921 A1	7/2015	Amidei et al.
2015/0189017 A1	7/2015	Amidei et al.
2015/0189373 A1	7/2015	Amidei et al.
2015/0288996 A1	10/2015	Van Der Schaar et al.
2015/0334435 A1	11/2015	Shivadas et al.
2015/0373421 A1*	12/2015	Chan H04N 21/2351
		380/239
2016/0070890 A1	3/2016	Grab et al.
2016/0112382 A1	4/2016	Kiefer et al.
2016/0149981 A1	5/2016	Shivadas et al.
2016/0219303 A1	7/2016	Braness et al.
2017/0214947 A1	7/2017	Kiefer et al.
2018/0007451 A1	1/2018	Shivadas et al.
2018/0060543 A1	3/2018	Grab et al.
2018/0131980 A1	5/2018	Van Der Schaar et al.
2018/0220153 A1	8/2018	Braness et al.

FOREIGN PATENT DOCUMENTS

CN	1221284 A	6/1999
CN	1723696	1/2006
EP	757484 A2	2/1997
EP	813167 A2	12/1997
EP	0936812 A1	8/1999
EP	1056273 A2	11/2000
EP	1187483 A2	3/2002
EP	1420580 A1	5/2004
EP	1553779 A1	7/2005
EP	1657835 A1	5/2006

US 10,212,486 B2

Page 7

(56)   **References Cited**

FOREIGN PATENT DOCUMENTS

EP	1718074	A1	11/2006
EP	2486517	A1	8/2012
EP	2486727	A1	8/2012
EP	2507995	A1	10/2012
EP	2564354	A1	3/2013
EP	2616991		7/2013
EP	2617192		7/2013
EP	2661696	A1	11/2013
EP	2661875	A1	11/2013
EP	2661895	A2	11/2013
EP	2486727	A4	3/2014
EP	2564354	A4	3/2014
EP	2616991	A4	3/2014
EP	2617192	A4	3/2014
EP	2716048	A1	4/2014
EP	2721826	A1	4/2014
EP	2486517		6/2014
EP	2751990		7/2014
EP	2807821		12/2014
EP	2751990	A1	4/2015
HK	1125765	A	8/2009
JP	08046902	A	2/1996
JP	8111842	A	4/1996
JP	08163488		6/1996
JP	08287613	A	11/1996
JP	09037225	A	2/1997
JP	11164307	A	6/1999
JP	11275576	A	10/1999
JP	11328929	A	11/1999
JP	2000201343	A	7/2000
JP	02001043668	A	2/2001
JP	2001209726	A	8/2001
JP	2001346165	A	12/2001
JP	2002164880	A	6/2002
JP	2002170363		6/2002
JP	2002170363	A	6/2002
JP	2002518898	A	6/2002
JP	2002218384	A	8/2002
JP	2003179597	A	6/2003
JP	2003250113	A	9/2003
JP	2004013823	A	1/2004
JP	2004515941	A	5/2004
JP	2004172830	A	6/2004
JP	2004187161	A	7/2004
JP	2004234128	A	8/2004
JP	2005027153		1/2005
JP	2005080204	A	3/2005
JP	2006155500	A	6/2006
JP	2006524007	A	10/2006
JP	2007036666	A	2/2007
JP	2007174375	A	7/2007
JP	2007235690	A	9/2007
JP	2007535881	A	12/2007
JP	2008235999	A	10/2008
JP	2009530917	A	8/2009
JP	5200204	B2	6/2013
JP	2014506430	A	3/2014
JP	5723888	B2	4/2015
JP	6038805	B2	12/2016
JP	6078574	B2	1/2017
JP	2017063453		3/2017
KR	100221423	B1	6/1999
KR	100221423		9/1999
KR	2002013664		2/2002
KR	1020020064888	A	8/2002
KR	100669616		9/2007
KR	1020130133830		12/2013
KR	101874907	B1	7/2018
SG	146026		12/2010
WO	1995015660	A1	6/1995
WO	1996013121		5/1996
WO	1997031445	A3	4/1998
WO	1999010836	A1	3/1999
WO	1999065239	A2	12/1999
WO	0104892	A1	1/2001

WO	2001031497	A1	5/2001
WO	2001050732	A2	7/2001
WO	2001065762	A2	9/2001
WO	2002001880	A1	1/2002
WO	2002008948	A2	1/2002
WO	2002035832	A2	5/2002
WO	2002037210	A2	5/2002
WO	2002054196	A2	7/2002
WO	2003030000	A1	4/2003
WO	2003096136	A2	11/2003
WO	2004054247	A1	6/2004
WO	2004097811	A1	11/2004
WO	2004102571	A1	11/2004
WO	2006018843	A2	2/2006
WO	2006018843	A3	12/2006
WO	2007044590	A2	4/2007
WO	2007113836	A2	10/2007
WO	2008010275	A1	1/2008
WO	2008042242	A2	4/2008
WO	2008086313	A1	7/2008
WO	2007113836	A3	11/2008
WO	2008135932	A2	11/2008
WO	2007113836	B1	12/2008
WO	2009065137	A1	5/2009
WO	2010060106	A1	5/2010
WO	2010080911	A1	7/2010
WO	2010089962	A1	8/2010
WO	2010108053	A1	9/2010
WO	2010111261	A1	9/2010
WO	2010122447	A1	10/2010
WO	2010147878	A1	12/2010
WO	2011042898	A1	4/2011
WO	2011042900	A1	4/2011
WO	2011068668	A1	6/2011
WO	2011103364	A1	8/2011
WO	2011132184	A1	10/2011
WO	2011135558	A1	11/2011
WO	2012035533	A2	3/2012
WO	2012035534	A2	3/2012
WO	2012035534	A3	7/2012
WO	2012094171	A1	7/2012
WO	2012094181	A2	7/2012
WO	2012094189	A1	7/2012
WO	20120094181	A2	7/2012
WO	20120094189	A1	7/2012
WO	2012035533	A3	8/2012
WO	2012162806	A1	12/2012
WO	2012171113	A1	12/2012
WO	2013030833	A1	3/2013
WO	2013032518	A2	3/2013
WO	2013103986	A2	7/2013
WO	2013111126	A2	8/2013
WO	2013111126	A3	8/2013
WO	2013032518	A3	9/2013
WO	2013144942	A1	10/2013
WO	2014145901	A1	9/2014
WO	2014193996	A2	12/2014
WO	2014193996	A3	2/2015
WO	2015031982	A1	3/2015

OTHER PUBLICATIONS

Windows Media Center Extender for Xbox, printed May 9, 2007 from http://www.xbox.com/en-US/support/systemuse/xbox/console/mediacenterextender.htm, 2 pgs.
Windows® XP Media Center Edition 2005, "Experience more entertainment", retrieved from http://download.microsoft.com/download/c/9/a/c9a7000a-66b3-455b-860b-1c16f2eecfec/MCE.pdf on May 9, 2007, 2 pgs.
"Adaptive Streaming Comparison", Jan. 28, 2010, 5 pgs.
"Best Practices for Multi-Device Transcoding", Kaltura Open Source Video, Printed on Nov. 27, 2013 from knowledge.kaltura.com/best-practices-multi-device-transcoding, 13 pgs.
"Container format (digital)", printed Aug. 22, 2009 from http://en.wikipedia.org/wiki/Container_format_(digital), 4 pgs.
"Diagram | Matroska", Dec. 17, 2010, Retrieved from http://web.archive.org/web/201 01217114656/http:I/matroska.org/technical/diagram/index.html on Jan. 29, 2016, 5 pages, Dec. 17, 2010.

US 10,212,486 B2

Page 8

(56)   **References Cited**

OTHER PUBLICATIONS

"DVD—MPeg differences", printed Jul. 2, 2009 from http://dvd.sourceforge.net/dvdinfo/dvdmpeg/html, 1 pg.

"DVD subtitles", sam.zoy.org/writings/dvd/subtitles, dated Jan. 9, 2001, printed Jul. 2, 2009, 4 pgs.

"Final Committee Draft of MPEG-4 streaming text format", International Organisation for Standardisation, Feb. 2004, 22 pgs.

"IBM Spearheading Intellectual Property Protection Technology for Information on the Internet; Cryptolope Containers Have Arrived", May 1, 1996, Business Wire, Printed on Aug. 1, 2014 from http://www.thefreelibrary.com/IBM+Spearheading+Intellectual+Property+Protection+Technology+for...-a018239381, 6pg.

"Information Technology—Coding of audio-visual objects—Part 17: Streaming text", International Organisation for Standardisation, Feb. 2004, 22 pgs.

"Information technology—Coding of audio-visual objects—Part 18: Font compression and streaming", ISO/IEC 14496-18, First edition Jul. 1, 2004, 26 pgs.

"Innovation of technology arrived", Retrieved from http://www.iodata.com/catalogs/AVLP2DVDLA_Flyer200505.pdf on May 30, 2013, 2 pgs., I-O Data, 2 pgs.

"KISS Players, KISS DP-500", retrieved from http://www.kiss-technology.com/?p=dp500 on May 4, 2007, 1 pg.

"Matroska Streaming | Matroska", Retrieved from the Internet: URL:http://web.archive.org/web/2010121711431 O/http://matroska.org/technical!streaming/index.html [retrieved on Jan. 29, 2016], Dec. 17, 2010.

"Netflix turns on subtitles for PC, Mac streaming", Yahoo! News, Apr. 21, 2010, Printed on Mar. 26, 2014, 3 pgs.

"OpenDML AVI File Format Extensions", OpenDML AVI M-JPEG File Format Subcommittee, retrieved from www.the-labs.com/Video/odmlff2-avidef.pdf, Sep. 1997, 42 pgs.

"QCast Tuner for PS2, printed May 11, 2009 from http://web.archive.org/web/20030210120605/www.divx.com/software/detail.php?ie=39, 2 pgs".

"Smooth Streaming Client", The Official Microsoft IIS Site, Sep. 24, 2010, 4 pages.

"Specifications | Matroska", Retrieved from the Internet: URL:http://web.archive.org/web/201 00706041303/http:/1www.matroska.org/technical/specs/index.html [retrieved on Jan. 29, 2016, Jul. 6, 2010.

"Supplementary European Search Report for Application No. EP 10834935, International Filing Date Nov. 15, 2010, Search Completed May 27, 2014, 9 pgs."

"Supported Media Formats", Supported Media Formats, Android Developers, Printed on Nov. 27, 2013 from developer.android.com/guide/appendix/media-formats.html, 3 pgs.

"Text of ISO/IEC 14496-18/COR1, Font compression and streaming", ITU Study Group 16—Video Coding Experts Group—ISO/IEC MPEG & ITU-T VCEG(ISO/IEC JTC1/SC29/WG11 and ITU-T SG16 06), No. N8664, Oct. 27, 2006, 8 pgs.

"Text of ISO/IEC 14496-18/FDIS, Coding of Moving Pictures and Audio", ITU Study Group 16—Videocoding Experts Group—ISO/IEC MPEG & ITU-T VCEG(ISO/IEC JTC1/SC29/WG11 and ITU-T SG16 06), No. N6215, Dec. 2003, 26 pgs.

"Thread: SSME (Smooth Streaming Medial Element) config.xml review (Smooth Streaming Client configuration file)", Printed on Mar. 26, 2014, 3 pgs.

"Transcoding Best Practices", From movideo, Printed on Nov. 27, 2013 from code.movideo.com/Transcoding_Best_Practices, 5 pgs.

"Using HTTP Live Streaming", iOS Developer Library, http://developer.apple.com/library/ios#documentation/networkinginternet/conceptual/streamingmediaguide/UsingHTTPLiveStreaming/UsingHTTPLiveStreaming.html#//apple_ref/doc/uid/TP40008332-CH102-SW1, Feb. 11, 2014, 10 pgs.

"Video Manager and Video Title Set IFO file headers", printed Aug. 22, 2009 from http://dvd.sourceforge.net/dvdinfo/ifo.htm, 6 pgs.

"What is a DVD?", printed Aug. 22, 2009 from http://www.videohelp.com/dvd, 8 pgs.

"What is a VOB file", http://www.mpucoder.com/DVD/vobov.html, printed on Jul. 2, 2009, 2 pgs.

"What's on a DVD?", printed Aug. 22, 2009 from http://www.doom9.org/dvd-structure.htm, 5 pgs.

U.S. Appl. No. 13/224,298, "Final Office Action Received", dated May 19, 2014, 26 pgs.

U.S. Appl. No. 13/905,804, "Non-Final Office Action Received", dated Jul. 25, 2014, 14 pgs.

Akhshabi et al., "An Experimental Evaluation of Rate-Adaptation Algorithms in Adaptive Streaming over HTTP", MMSys'11, Feb. 23-25, 2011, 12 pgs.

Anonymous, "Method for the encoding of a compressed video sequence derived from the same video sequence compressed at a different bit rate without loss of data", ip.com, ip.com No. IPCOM000008165D, May 22, 2002, pp. 1-9.

Author Unknown, "Blu-ray Disc—Blu-ray Disc—Wikipedia, the free encyclopedia", printed Oct. 30, 2008 from http://en.wikipedia.org/wiki/Blu-ray_Disc, 11 pgs.

Author Unknown, "Blu-ray Movie Bitrates Here—Blu-ray Forum", printed Oct. 30, 2008 from http://forum.blu-ray.com/showthread.php?t=3338, 6 pgs.

Author Unknown, "MPEG-4 Video Encoder: Based on International Standard ISO/IEC 14496-2", Patni Computer Systems, Ltd., printed Jan. 24, 2007, USA, pp. 1-15.

Author Unknown, "O'Reilly—802.11 Wireless Networks: The Definitive Guide, Second Edition", printed Oct. 30, 2008 from http://oreilly.com/catalog/9780596100520, 2 pgs.

Author Unknown, "Tunneling QuickTime RTSP and RTP over HTTP", Published by Apple Computer, Inc.: 1999 (month unknown), 6 pages.

Author Unknown, "Turbo-Charge Your Internet and PC Performance", printed Oct. 30, 2008 from Speedtest.net—The Global Broadband Speed Test, 1 pg.

Author Unknown, "When is 54 Not Equal to 54? A Look at 802.11a, b and g Throughput", printed Oct. 30, 2008 from www.oreillynet.com/pub/a/wireless/2003/08/08/wireless_throughput.html, 4 pgs.

Author Unknown, "White paper, The New Mainstream Wireless LAN Standard", Broadcom Corporation, Jul. 2003, 12 pgs.

Blasiak, Video Transrating and Transcoding: Overview of Video Transrating and Transcoding Technologies, Ingenient Technologies, TI Developer Conference, Aug. 6-8, 2002, 22 pgs.

Casares et al., "Simplifying Video Editing Using Metadata", DIS2002, 2002, pp. 157-166.

Deutscher, "IIS Transform Manager Beta—Using the MP4 to Smooth Task", Retrieved from: https://web.archive.org/web/20130328111303/http://blog.johndeutscher.com/category/smooth-streaming, Blog post of Apr. 17, 2010, 14 pgs.

Gannes, "The Lowdown on Apple's HTTP Adaptive Bitrate Streaming", GigaOM, Jun. 10, 2009, 12 pgs.

Garg et al., "An Experimental Study of Throughput for UDP and VoIP Traffic in IEEE 802.11b Networks", Wireless Communications and Networkings, Mar. 2003, pp. 1748-1753.

Ghosh, "Enhancing Silverlight Video Experiences with Contextual Data", Retrieved from: http://msdn.microsoft.com/en-us/magazine/ee336025.aspx, 2010, 15 pgs.

Griffith, Eric, "Wi-Fi Planet, The Wireless Digital Picture Fram Arrives", printed May 4, 2007 from http://www.wi-fiplanet.com/news/article.php/3093141, Oct. 16, 2003, 3 pgs.

Inlet Technologies, "Adaptive Delivery to iDevices", 2010, 2 pages.

Inlet Technologies, "Adaptive delivery to iPhone 3.0", 2009, 2 pgs.

Inlet Technologies, "HTTP versus RTMP", 2009, 3 pages.

Inlet Technologies, "The World's First Live Smooth Streaming Event: The French Open", 2009, 2 pages.

"IBM Closes Cryptolopes Unit," Dec. 17, 1997, CNET News, Printed on Apr. 25, 2014 from http://news.cnet.com/IBM-closes-Cryptolopes-unit/2100-1001_3206465.html, 3 pages.

"Information Technology—Coding of Audio Visual Objects—Part 2: Visual" International Standard, ISO/IEC 14496-2, Third Edition, Jun. 1, 2004, pp. 1-724. (presented in three parts).

"OpenDML AVI File Format Extensions," Sep. 1997, Version 1.02, XP-002179318, OpenDML AVI M-JPEG File Format Subcommitee, 42 pgs.

Broadq—The Ultimate Home Entertainment Software, printed May 11, 2009 from ittp://web.srchive.org/web/20030401122010/www.broadq.com/qcasttuner/, 1 pg.

US 10,212,486 B2

Page 9

(56)   **References Cited**

OTHER PUBLICATIONS

Cloakware Corporation, "Protecting Digital Content Using Cloakware Code Transformation Technology", Version 1.2, May 2002, pp. 1-10.

European Search Report Application No. EP 08870152, Search Completed May 19, 2011, dated May 26, 2011, 9pgs.

European Search Report for Application 11855103.5, search completed Jun. 26, 2014, 9 pgs.

European Search Report for Application 11855237.1, search completed Jun. 12, 2014, 9 pgs.

European Supplementary Search Report for Application EP09759600, completed Jan. 25, 2011, 11 pgs.

Extended European Search Report for European Application EP10821672, completed Jan. 30, 2014, 3 pgs.

Extended European Search Report for European Application EP11824682, completed Feb. 6, 2014, 4 pgs.

Extended European Search Report for European Application No. 14763140.2, Search completed Sep. 26, 2016, dated Oct. 5, 2016, 9 Pgs.

Federal Computer Week, "Tool Speeds Info to Vehicles", Jul. 25, 1999, 5 pages.

HTTP Live Streaming Overview, Networking & Internet, Apple, Inc., Apr. 1, 2011, 38 pages.

IBM Corporation and Microsoft Corporation, "Multimedia Programming Interface and Data Specifications 1.0", Aug. 1991, printed from http://www.kk.iij4u.or.jp/~kondo/wave/mpidata.txt on Mar. 6, 2006, 100 pgs.

InformationWeek, "Internet on Wheels", InformationWeek: Front End: Daily Dose, Jul. 20, 1999, Printed on Mar. 26, 2014, 3 pgs.

International Preliminary Report on Patentability for International Application PCT/US14/30747, Report dated Sep. 15, 2015, dated Sep. 24, 2015, 6 Pgs.

International Preliminary Report on Patentability for International Application No. PCT/US2008/083816, dated May 18, 2010, 6 pgs.

International Preliminary Report on Patentability for International Application No. PCT/US2011/068276, dated Mar. 4, 2014, 23 pgs.

International Preliminary Report on Patentability for International Application PCT/US2013/043181, dated Dec. 31, 2014, dated Jan. 8, 2015, 11 Pgs.

International Preliminary Report on Patentability for International Application PCT/US2014/039852, dated Dec. 1, 2015, dated Dec. 5, 2015, 8 Pgs.

International Search Report and Written Opinion for International Application No. PCT/US08/87999, completed Feb. 7, 2009, dated Mar. 19, 2009, 6 pgs.

International Search Report and Written Opinion for International Application No. PCT/US09/46588, completed Jul. 13, 2009, dated Jul. 23, 2009, 7 pgs.

International Search Report and Written Opinion for International Application No. PCT/US2005/025845, completed Feb. 5, 2007 and dated May 10, 2007, 8 pgs.

International Search Report and Written Opinion for International Application No. PCT/US2008/083816, completed Jan. 10, 2009, dated Jan. 22, 2009, 7 pgs.

International Search Report and Written Opinion for International Application No. PCT/US2010/020372, Completed Feb. 10, 2009, dated Mar. 1, 2010, 8 pgs.

International Search Report and Written Opinion for International Application No. PCT/US2010/56733, Completed Jan. 3, 2011, dated Jan. 14, 2011, 9 pgs.

International Search Report and Written Opinion for International Application No. PCT/US2013/043181, completed Nov. 27, 2013, dated Dec. 6, 2013, 12 pgs.

International Search Report and Written Opinion for International Application PCT/US14/30747, completed Jul. 30, 2014, dated Aug. 22, 2014, 7 Pgs.

International Search Report and Written Opinion for International Application PCT/US14/39852, completed Oct. 21, 2014, dated Dec. 5, 2014, 11 pgs.

International Search Report and Written Opinion for International Application PCT/US2011/066927, completed Apr. 3, 2012, dated Apr. 20, 2012, 14 pgs.

International Search Report and Written Opinion for International Application PCT/US2011/067167, completed Jun. 19, 2012, dated Jul. 2, 2012, 11 pgs.

International Search Report and Written Opinion for International Application PCT/US2011/068276, completed Jun. 19, 2013, dated Jul. 8, 2013, 24 pgs.

International Search Report and Written Opinion for PCT/US2013/020572, International Filing Date Jan. 7, 2013, Search Completed Mar. 19, 2013, dated Apr. 29, 2013, 10 pgs.

ITS International, "Fleet System OPTS for Mobile Server", Aug. 26, 1999, Printed on Oct. 21, 2011 from http://www.itsinternational.com/News/article.cfm?recordID=547, 1 page.

Lifehacker—Boxqueue Bookmarklet Saves Videos for Later Boxee Watching, printed Jun. 16, 2009 from http://feeds.gawker.com/~r/lifehacker/full/~3/OHvDmrIgZZc/boxqueue-bookmarklet-saves-videos-for-late-boxee-watching, 2 pgs.

Linksys Wireless-B Media Adapter Reviews, printed May 4, 2007 from http://reviews.cnet.com/Linksys_Wireless_B_Media_Adapter/4505-6739_7-30421900.html?tag=box, 5 pgs.

Linksys, KISS DP-500, printed May 4, 2007 from http://www.kiss-technology.com/?p=dp500, 2 pgs.

Linksys®: "Enjoy your digital music and pictures on your home entertainment center, without stringing wires!", Model No. WMA 11B, printed May 9, 2007 from http://www.linksys.com/servlet/Satellite?c=L_Product_C2&childpagename=US/Layout&cid=1115416830950&p.

Microsoft Corporation, "Chapter 8, Multimedia File Formats" 1991, Microsoft Windows Multimedia Programmer's Reference, 3 cover pgs, pp. 8-1 to 8-20.

Microsoft Media Platform: Player Framework, "Microsoft Media Platform: Player Framework v2.5 (formerly Silverlight Media Framework)", May 3, 2011, 2 pages.

Microsoft Media Platform: Player Framework, "Silverlight Media Framework v1.1", Jan. 2010, 2 pages.

Microsoft Windows® XP Media Center Edition 2005, Frequently asked Questions, printed May 4, 2007 from http://www.microsoft.com/windowsxp/mediacenter/evaluation/faq.mspx.

Microsoft Windows® XP Media Center Edition 2005: Features, printed May 9, 2007, from http://www.microsoft.com/windowsxp/mediacenter/evaluation/features.mspx, 4 pgs.

Office Action for Chinese Patent Application No. CN200880127596.4, dated May 6, 2014, 15 pgs.

Office Action for U.S. Appl. No. 13/223,210, dated Apr. 30, 2015, 14 pgs.

Office Action for U.S. Appl. No. 14/564,003, dated Apr. 17, 2015, 28 pgs.

Open DML AVI-M-JPEG File Format Subcommittee, "Open DML AVI File Format Extensions", Version 1.02, Feb. 28, 1996, 29 pgs.

PC world.com, Future Gear: PC on the HiFi, and the TV, from http://www.pcworld.com/article/id,108818-page,1/article.html, printed May 4, 2007, from IDG Networks, 2 pgs.

QTV—About BroadQ, printed May 11, 2009 from http://www.broadq.com/en/about.php, 1 pg.

Supplementary European Search Report for Application No. EP 04813918, Search Completed Dec. 19, 2012, 3 pgs.

Supplementary European Search Report for Application No. EP 10729513, completed Dec. 9, 2013, 4 pgs.

Supplementary European Search Report for EP Application 11774529, completed Jan. 31, 2014, 2 pgs.

Kaspar et al., "Using HTTP Pipelining to Improve Progressive Download over Multiple Heterogeneous Interfaces", IEEE ICC proceedings, 2010, 5 pgs.

Kim, Kyuheon, "MPEG-2 ES/PES/TS/PSI", Kyung-Hee University, Oct. 4, 2010, 66 pages.

Kozintsev et al., "Improving last-hop multicast streaming video over 802.11", Workshop on Broadband Wireless Multimedia, Oct. 2004, pp. 1-10.

Kurzke et al., "Get Your Content Onto Google TV", Google, Retrieved from: http://commondatastorage.googleapis.com/io2012/presentations/live%20to%20website/1300.pdf, 2012, 58 pgs.

Appx28

US 10,212,486 B2

Page 10

(56)   **References Cited**

OTHER PUBLICATIONS

Lang, "Expression Encoder, Best Practices for live smooth streaming broadcasting", Microsoft Corporation, 2010, retrieved from http://www.streamingmedia.com/conferences/west2010/presentations/SMWest-12010-Expression-Encoder.pdf, 20 pgs.

Levkov, "Mobile Encoding Guidelines for Android Powered Devices", Adobe Systems Inc., Addendum B, Dec. 22, 2010, 42 pgs.

Long et al., "Silver: Simplifying Video Editing with Metadata", CHI 2003: New Horizons, Apr. 5-10, 2003, pp. 628-629.

Morrison, "EA IFF 85 Standard for Interchange Format Files", Jan. 14, 1985, printed from http://www.dcs.ed.ac.uk/home/mxr/gfx/2d/IFF.txt on Mar. 6, 2006, 24 pgs.

MSDN, "Adaptive streaming, Expression Studio 2.0", Apr. 23, 2009, 2 pgs.

Nelson, "Smooth Streaming Deployment Guide", Microsoft Expression Encoder, Aug. 2010, 66 pgs.

Nelson, Mark, "Arithmetic Coding + Statistical Modeling = Data Compression: Part 1—Arithmetic Coding", Doctor Dobb's Journal, Feb. 1991, printed from http://www.dogma.net/markn/articles/arith/partl.htm; printed Jul. 2, 2003, 12 pgs.

Nelson, Michael, "IBM's Cryptolopes", Complex Objects in Digital Libraries Course, Spring 2001, Retrieved from http://www.cs.odu.edu/~mln/teaching/unc/inls210/?method=display&pkg_name=cryptolopes.pkg&element_name=cryptolopes.ppt, 12 pages.

Noboru, "Play Fast and Fine Video on Web! codec", Co.9 No. 12, Dec. 1, 2003, pp. 178-179.

Noe, A., "Matroska File Format (under construction!)", Retrieved from the Internet: URL:http://web.archive.orgweb/20070821155146/www.matroska.org/technical/specs/matroska.pdf [retrieved on Jan. 19, 2011], Jun. 24, 2007, 1-51.

Noe, Alexander, "AVI File Format", http://www.alexander-noe.com/video/documentation/avi.pdf, Dec. 14, 2006, pp. 1-26.

Noe, Alexander, "Definitions", Apr. 11, 2006, retrieved from http://www.alexander-noe.com/video/amg/definitions.html on Oct. 16, 2013, 2 pages.

Ooyala, "Wdevine Content Protection", Ooyala Support Center for Developers. Ooyala, Inc., 2013. Jun. 3, 2013. http://support.ooyala.com/developers/documentation/concepts/player_v3_widevine_integration.html.

Ozer, "The 2012 Encoding and Transcoding Buyers' Guide", Streamingmedia.com, Retrieved from: http://www.streamingmedia.com/Articles/Editorial/Featured-Articles/The-2012-Encoding-and-Transcoding-Buyers-Guide-84210.aspx, 2012, 8 pgs.

Pantos, "HTTP Live Streaming, draft-pantos-http-live-streaming-10", IETF Tools, Oct. 15, 2012, Retrieved from: http://tools.ietf.org/html/draft-pantos-http-live-streaming-10, 37 pgs.

Pantos, R., "HTTP Live Streaming: draft-pantos-http-live-streaming-06", Published by the Internet Engineering Task Force (IETF), Mar. 31, 2011, 24 pages.

Papagiannaki et al., "Experimental Characterization of Home Wireless Networks and Design Implications", INFOCOM 2006, 25th IEEE International Conference of Computer Communications, Proceedings, Apr. 2006, 13 pgs.

Phamdo, Nam, "Theory of Data Compression", printed from http://www.data-compression.com/theoroy.html on Oct. 10, 2003, 12 pgs.

RGB Networks, "Comparing Adaptive HTTP Streaming Technologies", Nov. 2011, Retrieved from: http://btreport.net/wp-content/uploads/2012/02/RGB-Adaptive-HTTP-Streaming-Comparison-1211-01.pdf, 20 pgs.

Schulzrinne, H., "Real Time Streaming Protocol 2.0 (RTSP): draft-ietfmmusic-rfc2326bis-27", MMUSIC Working Group of the Internet Engineering Task Force (IETF), 296 pgs. (presented in two parts), Mar. 9, 2011, 296 pages.

Siglin, "HTTP Streaming: What You Need to Know", streamingmedia.com, 2010, 15 pages.

Siglin, "Unifying Global Video Strategies, MP4 File Fragmentation for Broadcast, Mobile and Web Delivery", Nov. 16, 2011, 16 pgs.

Tan, Yap-Peng, et al., "Video transcoding for fast forward/reverse video playback", IEEE ICIP, 2002, pp. I-713 to I-716.

Unknown, "AVI RIFF File Reference (Direct X 8.1 C++ Archive)", printed from http://msdn.microsoft.com/archive/en-us/dx81_c/directx_cpp/htm/avirifffilereference.asp?fr . . . on Mar. 6, 2006, 7 pgs.

Unknown, "Entropy and Source Coding (Compression)", TCOM 570, Sep. 1999, pp. 1-22.

Wang et al., "Image Quality Assessment: From Error Visibility to Structural Similarity", IEEE Transactions on Image Processing, Apr. 2004, vol. 13, No. 4, pp. 600-612.

Wu, Feng et al., "Next Generation Mobile Multimedia Communications: Media Codec and Media Transport Perspectives", In China Communications, Oct. 2006, pp. 30-44.

Zambelli, Alex, "IIS Smooth Streaming Technical Overview", Microsoft Corporation, Mar. 2009.

U.S. Appl. No. 13/905,804, "Notice of Allowance," dated Aug. 12, 2015, 8 pgs.

EP11774529 Supplementary European Search Report, completed Jan. 31, 2014, 2 pgs.

Final draft ETSI ES 202 109, V1.1.1, ETSI Standard, Terrestrial Trunked Radio (TETRA); Security; Synchronization mechanism for end-to-end encryption, Oct. 2002, 17 pgs.

International Preliminary Report for Application No. PCT/US2011/066927, Filed Dec. 22, 2011, Report dated Jul. 10, 2013, 13 pgs.

International Preliminary Report for International Application No. PCT/US2011/067243, International Filing Date Dec. 23, 2011, dated Jul. 10, 2013, 7 pgs.

International Preliminary Report on Patentability for International Application PCT/US2011/067167, dated Feb. 25, 2014, 8 pgs.

International Search Report and Written Opinion for International Application No. PCT/US07/63950, completed Feb. 19, 2008; dated Mar. 19, 2008, 9 pgs.

International Search Report and Written Opinion for International Application No. PCT/US2004/041667, Completed May 24, 2007, dated Jun. 20, 2007, 6 pgs.

International Search Report and Written Opinion for International Application No. PCT/US2011/067243, International Filing Date Dec. 23, 2011, Search Completed Apr. 24, 2012, dated May 8, 2012, 8 pgs.

International Telecommunication Union, Telecommunication Standardization Sector of ITU, H.233, Line Transmission of Non-Telephone Signals, Confidentiality System for Audiovisual Services, ITU-T Recommendation H.233, Mar. 1993, 18 pgs.

Supplementary European Search Report for International Application No. PCT/US2007063950, Report Completed Jan. 25, 2013, 8 pgs.

Written Opinion for International Application No. PCT/US2005/025845 filed Jul. 21, 2005, report completed Feb. 5, 2007 and dated May 10, 2007, 5 pgs.

Written Opinion for International Application No. PCT/US2004/041667, Filing Date Dec. 8, 2004, Report Completed May 24, 2007, dated Jun. 20, 2007, 4 pgs.

Written Opinion for International Application No. PCT/US2007/063950 filed Mar. 14, 2007, report completed Mar. 1, 2008; report dated Mar. 19, 2008, 6 pgs.

Written Opinion for International Application No. PCT/US2008/083816, Opinion completed Jan. 10, 2009, dated Jan. 22, 2009, 5 pgs.

Written Opinion for International Application No. PCT/US2009/046588, completed Jul. 14, 2009, dated Jul. 23, 2009, 5 pgs.

Written Opinion of the International Searching Authority for International Application No. PCT/US2008/87999, date completed Feb. 7, 2009, dated Mar. 19, 2009, 4 pgs.

Invitation to Pay Add'l Fees Rcvd for International Application PCT/US14/39852, dated Sep. 25, 2014, 2 pgs.

3GPP TS 26.247, V1.3.0, 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects Transparent end-to-end Packet-switches Streaming Services (PSS);, Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-Dash) (Release 10), Mar. 2011, 72 pgs.

"Draft CR: Trick Mode for HTTP Streaming", 3GPP TSG-SA4 Meeting #58, Apr. 26-30, 2010, Vancouver, Canada, S4-100237, 3 pgs.

"DVD-MPEG differences", http://dvd.sourceforge.net/dvdinfo/dvdmpeg.html, printed on Jul. 2, 2009, 1 page.

US 10,212,486 B2

Page 11

(56)   References Cited

OTHER PUBLICATIONS

"Information Technology—Coding of audio-visual objects—Part 14: MP4 file format", International Standard, ISO/IEC 14496-14, First Edition, Nov. 15, 2003, 18 pgs.
"Information technology—Generic coding of moving pictures and associated audio information: Systems", International Standard ISO/IEC 13818-1, Second Edition, Dec. 1, 2000, 174 pgs.
"Information-Technology—Generic coding of moving pictures and associated audio: Systems, Recommendation H.222.0", International Standard, ISO/IEC 13818-1, Draft 1209, Apr. 25, 1995, 151 pgs.
"Information-Technology—Generic coding of moving pictures and associated audio: Systems, Recommendation H.222.0", International Standard, ISO/IEC 13818-1, Draft 1540, Nov. 13, 1994, 161 pgs.
"International Search Report and Written Opinion for International Application PCT/US2010/020372", Search Report dated Mar. 1, 2010, 7 pgs.
"Matroska", Wikipedia, Jul. 10, 2017, retrieved from https://en.wikipedia.org/wiki/Matroska on Jul. 20, 2017, 3 pgs.
"MovieLabs Specification for Next Generation Video—Version 1.0", Motion Picture Laboratories, Inc., 2013, Retrieved from: http://movielabs.com/ngvideo/MovieLabs%20Specification%20for%20Next%20Generation%20Video%20v1.0.pdf, 5 pgs.
"MPEG-2", Wikipedia, Jun. 13, 2017, retrieved from https://en.wikipedia.org/wiki/MPEG-2 on Jul. 20, 2017, 13 pgs.
"MPEG-4 File Format, Version 2", Sustainability of Digital Formats: Planning for Library of Congress Collections, Retrieved from: https://www.loc.gov/preservation/digital/formats/fdd/fdd000155.shtml, Last updated Feb. 21, 2017, 8 pgs.
"MPEG-4 Part 14", Wikipedia, Jul. 10, 2017, retrieved from https://en.wikipedia.org/wiki/MPEG-4_Part_14 on Jul. 20, 2017, 5 pgs.
"Series H: Audiovisual and Multimedia Systems Infrastructure of audiovisual services—Coding of moving video; High efficiency video coding", International Telecommunication Union, ITU-T H.265, Apr. 2015, 634 pgs.
"Specifications Matroska", Dec. 17, 2010, [retrieved on Mar. 2, 2018], 12 pgs.
Adams et al, "Will http adaptive streaming become the dominant mode of video delivery in cable networks?", https://www.nctatechnicalpapers.com/Paper/2011/2011-will-http-adaptive-streaming-become-the-dominant-mode-of-video-delivery-in-cable-networks-, 10 pgs.
Adhikari et al., "Unreeling Netflix: Understanding and Improving Multi-CDN Movie Delivery", 2012 Proceedings IEEE InfoCom, Mar. 25-30, 2012, Orlando, Florida, 9 pgs.
Adzic et al, "Optimized Adaptive HTTP Streaming for Mobile Devices", International Society for Optics and Photonics, Applications of Digital Image Processing XXXIV, vol. 8135, Sep. 2011, 10 pgs.
Bloom et al., "Protection for DVD Video", Proceedings of the IEEE, vol. 87, No. 7, Jul. 1999, pp. 1267-1276.
Bross et al., "High Efficiency Video Coding (HEVC) text specification draft 10 (for FDIS & Last Call)", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, Document: JCTVC-L1003_v34, 12th Meeting: Geneva, CH, Jan. 14-23, 2013 310 pgs.
Concolato et al., "Live HTTP Streaming of Video and Subtitles within a Browser", MMSys 2013, Feb. 26-Mar. 1, 2013, Oslo, Norway, 5 pgs.
Eskicioglu et al., "An Integrated Approach to Encrypting Scalable Video", Proceedings IEEE International Conference on Multimedia and Expo, Aug. 26-29, 2002, Lausanne, Switzerland, 4 pgs.
Fecheyr-Lippens, "A Review of HTTP Live Streaming", Internet Citation, Jan. 25, 2010, 38 pgs.

Hartung et al., "DRM Protected Dynamic Adaptive HTTP Streaming", MMSys 2011 Proceedings of the Second Annual ACM Conference on Multimedia Systems, San Jose, California, Feb. 23-25, 2011, pp. 277-282.
Hurtado Guzman, Juan Esteban, "Development and Implementation of an Adaptive HTTP Streaming Framework for H264/MVC Coded Media", Politecnico di Torino, Nov. 2010, 108 pgs.
Hwang et al., "Efficient and User Friendly Inter-domain Device Authentication/Access control for Home Networks", Proceedings of the 2006 International Conference on Embedded and Ubiquitous Computing, Seoul, Korea, Aug. 1-4, 2006, 10 pgs.
Li et al, "Content-Aware Playout and Packet Scheduling for Video Streaming Over Wireless Links", IEEE Transactions on Multimedia, vol. 10, No. 5, Aug. 2008, pp. 885-895.
Lian et al., "Efficient video encryption scheme based on advanced video coding", Multimed. Tools Appl. vol. 38, 2008, pp. 75-89.
Liu et al., "A Formal Framework for Component Deployment", OOPSLA 2006, Proceedings of the 21st Annual ACM SIGPLAN Conference on Object-Oriented Programming Systems, Language, and Applications, Portland, Oregon, Oct. 22-26, 2006, 19 pgs.
Matroska, "Diagram", Matroska, Technical/Info, Diagram, 2016, retrieved from https://www.matroska.org/technical/diagram/index.html on Jul. 20, 2017, 9 pgs.
Matroska, "Specifications", Matroska, Technical/Info, Specifications, Jun. 25, 2017, retrieved from https://www.matroska.org/technical/specs/index.html on Jul. 20, 2017, 20 pgs.
Miras, "On Quality Aware Adaptation of Internet Video", University of London, PhD dissertation, 2004, 181 pgs.
Moscoso, Pedro Gomes, "Interactive Internet TV Architecture Based on Scalable Video Coding", Instituto Superior Techico, Universidad Technica de Lisboa, May 2011, 103 pgs.
Oyman et al, "Quality of Experience for HTTP Adaptive Streaming Services", IEEE Communications Magazine, Apr. 2012, vol. 50, No. 4, DOI: 10.1109/MCOM.2012.6178830, 8 pgs.
Ozer, Jan, "Adaptive Streaming in the Field", Streaming Media, Dec. 2010-Jan. 2011, 9 pgs.
Padiadpu, Rashmi, "Towards Mobile Learning: A SCORM Player for the Google Android Platform", Master Thesis, Hamburg University of Applied Sciences, 2008, 66 pgs.
Peek, David, "Consumer Distributed File Systems", Dissertation, Doctor of Philosophy, Computer Science and Engineering, The University of Michigan, 2009, 118 pgs.
Rosenberg et al., "Indicating User Agent Capabilities in the Session Initiation Protocol (SIP)", Network Working Group, RFC 3840, Aug. 2004, 36 pgs.
Silvio, "adaptive HTTP streaming for open codecs", Oct. 9, 2010, retrieved on: Mar. 2, 2018, 15 pgs.
Tripathi et al, "Improving Multimedia Streaming with Content-Aware Video Scaling", Retrieved from: http://digitalcommons.wpi.edu/computerscience-pubs/96, 2001, 17 pgs.
Unknown, "MPEG-4 Video Encoder: Based on International Standard ISO/IEC 14496-2", Patni Computer Systems, Ltd., publication date unknown, 15 pgs.
Venkatramani et al., "Securing Media for Adaptive Streaming", Multimedia 2003 Proceedings of the Eleventh ACM International Conference on Multimedia, Nov. 2-8, 2003, Berkeley, California, 4 pgs.
"Microsoft Announces Breakthrough Technology Enabling Simple Access to Broad Set of Digital Content, Including Music, Games, Video, Ring Tones and Pictures", Microsoft, Feb. 12, 2017, Retrieved from https://news.microsoft.com/2007/02/12/microsoft-announces-breakthrough-technology-enabling-simple-access-to-broad-set-of-digital-content-including-music-games-video-ring-tones-and-pictures/, 5 pgs.
Bocharov et al., "Portable encoding of audio-video objects: The Protected Interoperable File Format (PIFF)", Microsoft Corporation, Sep. 8, 2009, Revised: Mar. 9, 2010, 32 pgs.

* cited by examiner
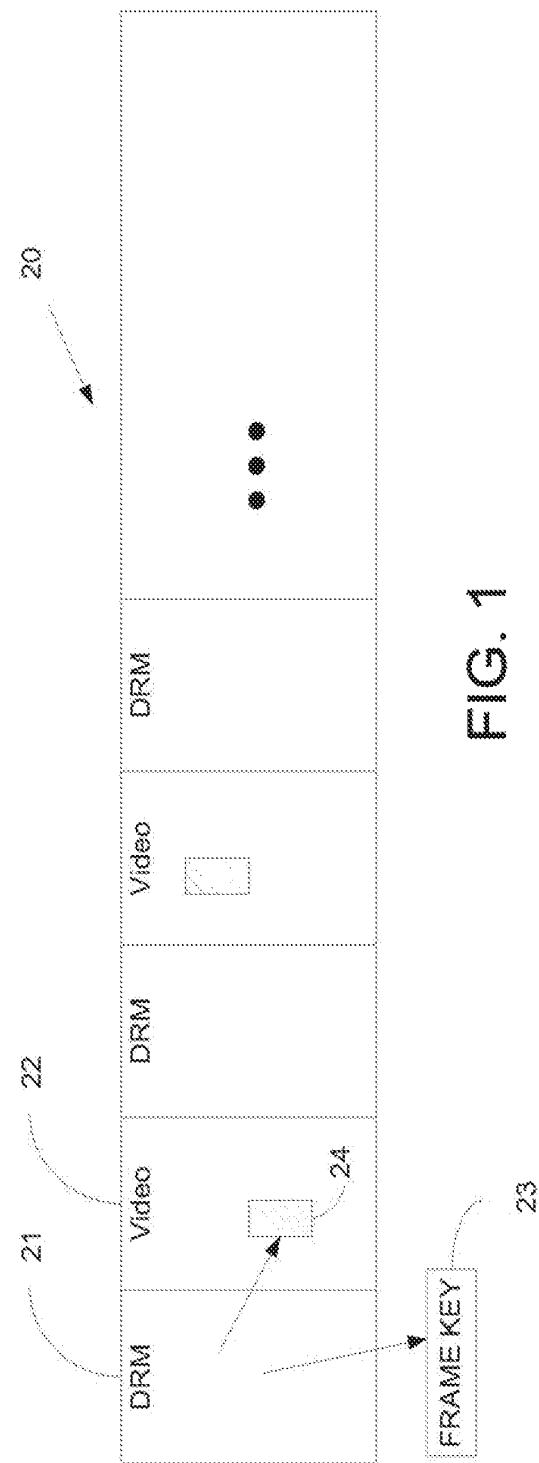
FIG. 1

FIG. 2

FIG. 3

FIG. 4

Receive the encrypted transmitted data
201

Decipher the received cryptographic information
202

Decrypt the encrypted video data utilizing the retrieved cryptographic information
203

Decode the decrypted video/audio data for playback
204

FIG. 5

FIG. 6

Appx37

302

304

306

Selected Heuristic → Key Material → Wrap Key

300

FIG. 7

Appx37

FIG. 8

US 10,212,486 B2

<table>
<tr><td>1</td><td>2</td></tr>
</table>
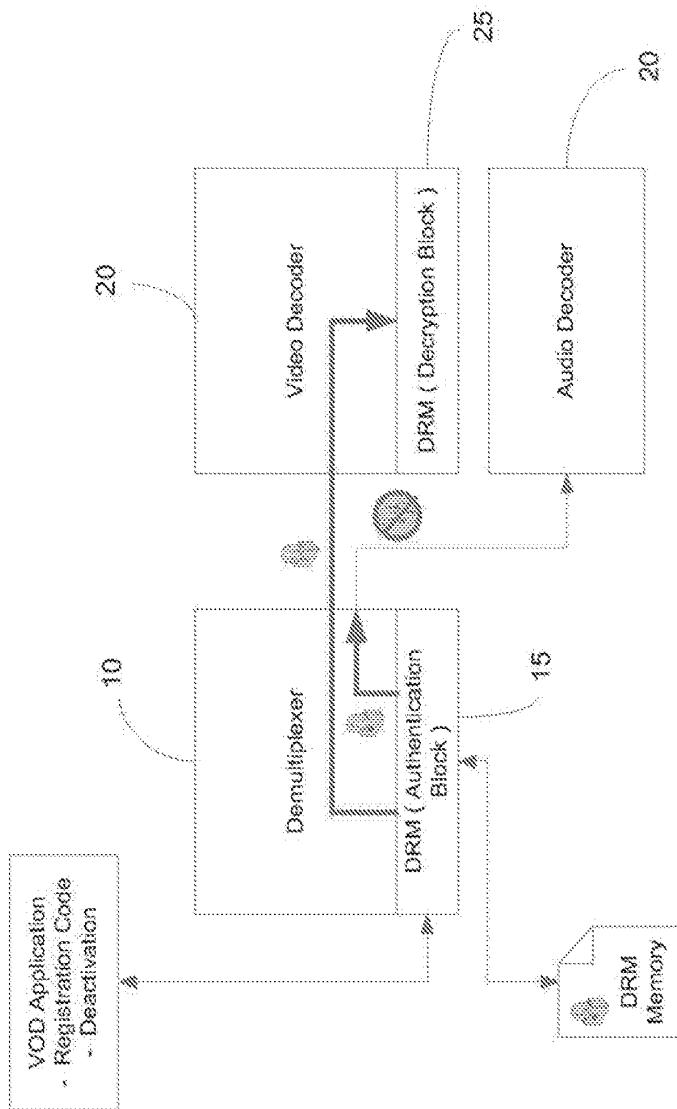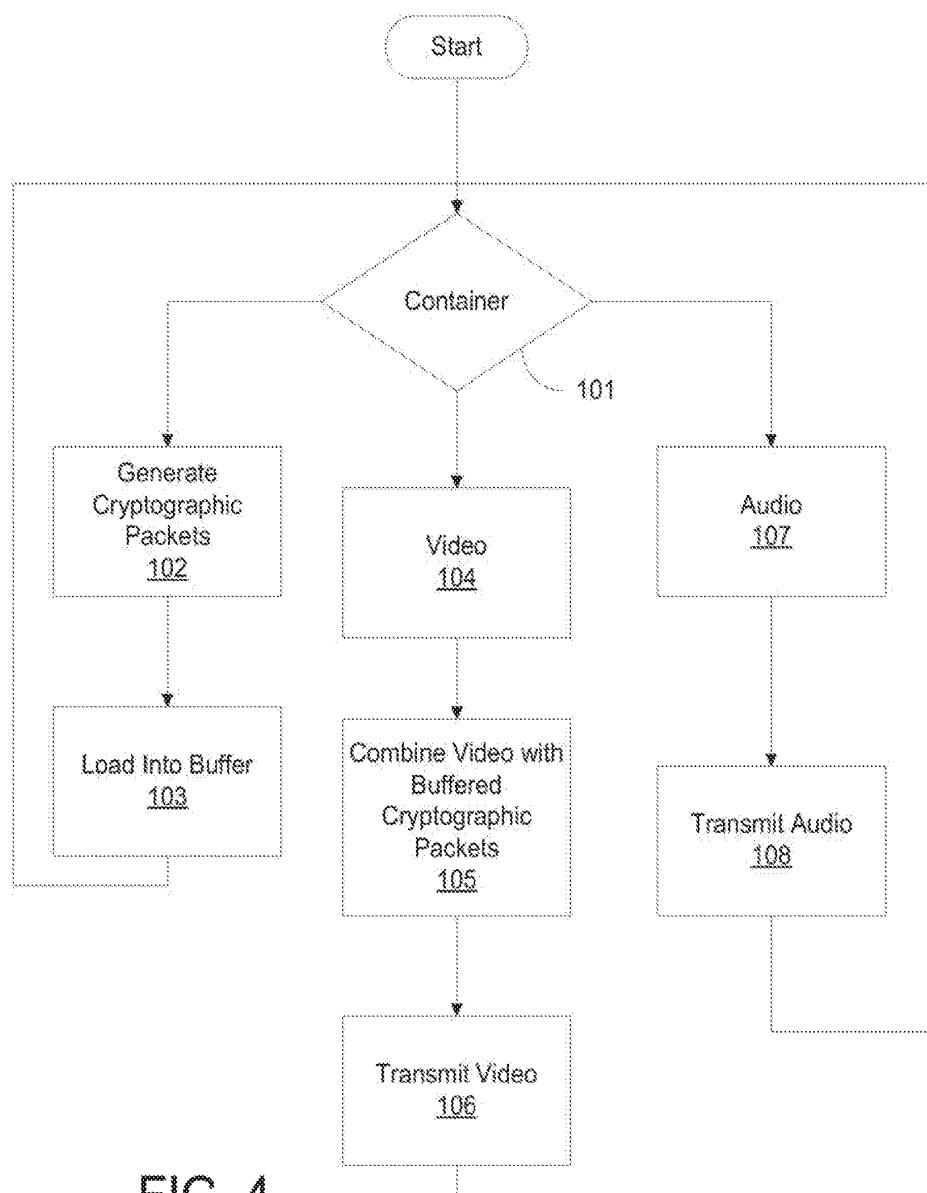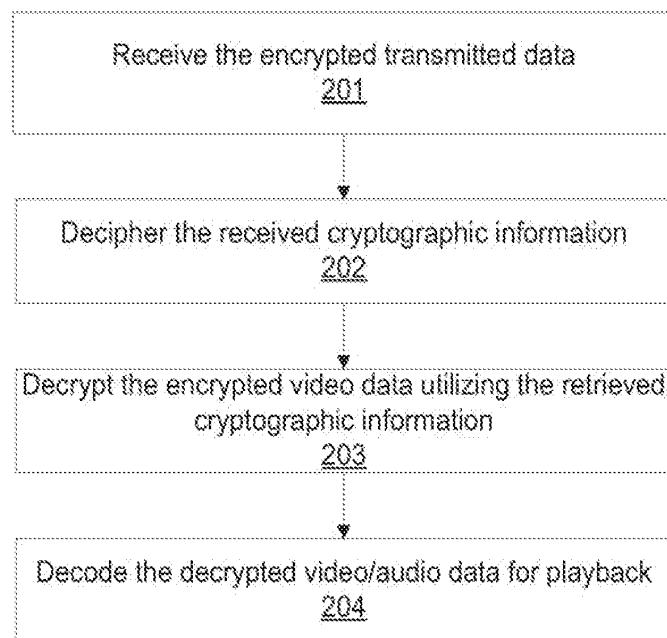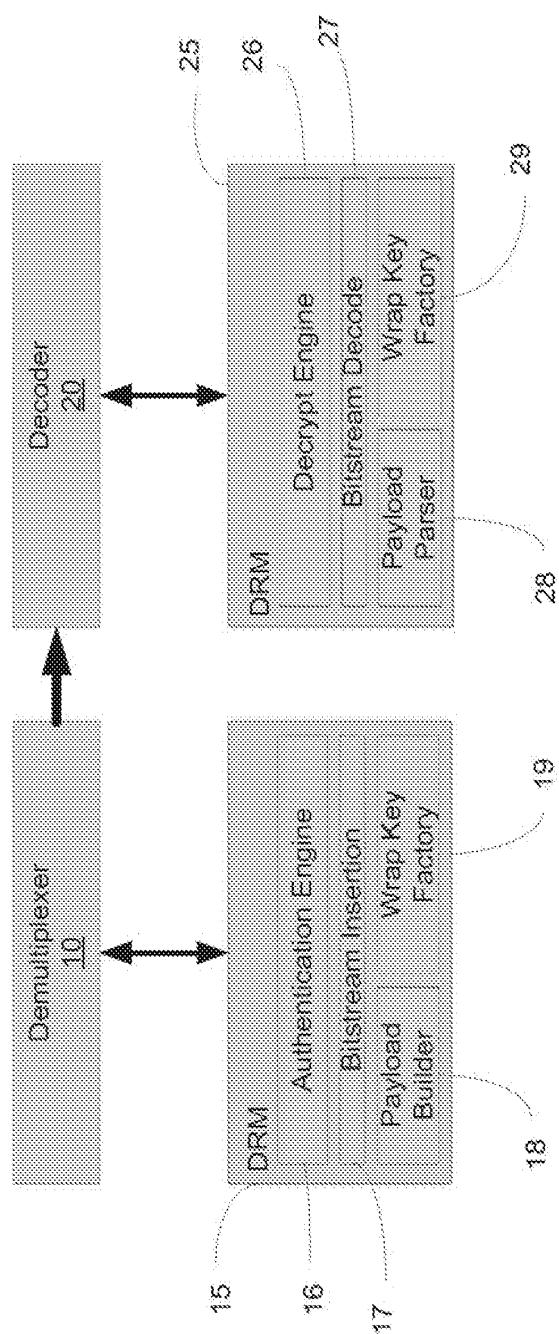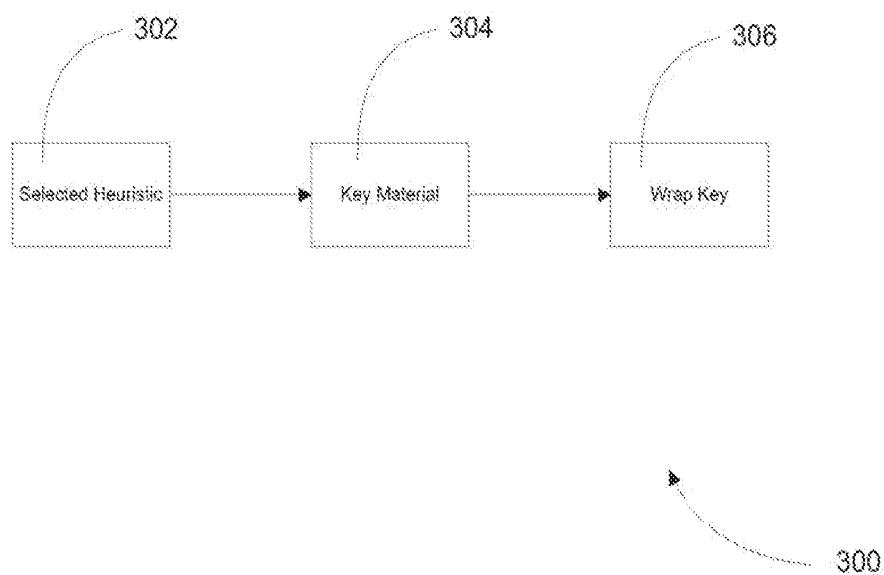
ELEMENTARY BITSTREAM CRYPTOGRAPHIC MATERIAL TRANSPORT SYSTEMS AND METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

The current application is a continuation application of U.S. application Ser. No. 14/839,783 filed Aug. 28, 2015 entitled "Elementary Bitstream Cryptographic Material Transport Systems and Methods" which application is a continuation of U.S. application Ser. No. 14/306,146 filed Jun. 16, 2014, and issued on Sep. 1, 2015 as U.S. Pat. No. 9,124,773, entitled "Elementary Bitstream Cryptographic Material Transport Systems and Methods" which application is a continuation application of U.S. application Ser. No. 12/946,631 filed Nov. 15, 2010, and issued on Jul. 15, 2014 as U.S. Pat. No. 8,781,122, entitled "Elementary Bitstream Cryptographic Material Transport Systems and Methods" which claims priority to U.S. Provisional Patent Application No. 61/266,982, filed Dec. 4, 2009, the disclosures of which are incorporated herein by reference.

BACKGROUND

The present invention generally relates to digital multimedia distribution systems and more specifically to digital transmission of encrypted multimedia content over an unsecured connection.

Providers of multimedia content can digitize content for distribution via digital communication networks. An important issue faced by a content distribution system is enabling only those customers that have purchased the content to play the content and compartmentalize access to all the stakeholders in the content distribution chain. One approach is to encrypt portions of the content and to issue encryption keys to authorized users that enable encrypted portions of the content to be unencrypted. Layers of keys and protection policies can be used so a single encryption key alone is insufficient for the user to access the content. In a number of systems, users purchase players that possess specified decryption capabilities. Content providers can distribute content to user's owning such a player in an encryption format supported by the player. Complying with a specified protection policy typically involves using an encryption key specified by the manufacturer of the players. In many instances the manufacturer of the players will not reveal the encryption keys used in the specified encryption scheme and likewise the content provider does not want to share the content keys to the manufacturer of the players.

Communications between components or processes of players or playback systems are typically trustworthy and secured. However, when communication or the transporting of information becomes unsecured or untrustworthy, such gaps need to be accounted for and filled. This has become more evident with advent and popularity of open multimedia frameworks. Bi-directional communication requirements and/or run time challenges and authentication requests to fill such gaps have proved to be less than adequate.

There are many ways of securing communication, including ciphering and encryption.

Ciphering is a procedure used to secure data that typically involves using a series of steps to scramble and render the data readable only to the intended audience. The procedure itself does not require an outside source, such as a key, in order to encipher or decipher the data. Rather, data can be properly deciphered by the intended audience so long as

deciphering exactly follows the enciphering steps to unravel the data. Encryption is a procedure used to secure data. That typically involves the use of an external input for at least one step in the procedure, such as a key, in order to secure and/or access the data. The external data is used to intentionally manipulate at least one step in the encryption or decryption process, changing the way the data processing for encryption occurs. Generally, without the external data or a corresponding decryption key in an encryption process, a step in a corresponding decryption process cannot properly be executed and the data cannot be properly decrypted.

In the context of digital media, encoding is a procedure by which digital media is represented in a digital format. The format is typically selected to obtain specific benefits during the transportation, playback and storage of the digital media format used. For example, representing the media using fewer bits may be beneficial to transfer data in order to minimize bandwidth usage or storage space. In another example, a media player may only decode or read media in a certain format and therefore the digital media may first be in that format in order to be decoded by that media player.

Decoding is a procedure by which digital media in a format is translated into a format readable by a media player for rendering on a display device. Often, decoding may also reverse processes associated with encoding such as compression. In instances where encryption and/or enciphering have been applied to encoded media, the enciphering process or encryption process typically must be reversed before the encoded media can be decoded.

SUMMARY OF THE INVENTION

Systems and methods are described for taking cryptographic material from a container file and inserting the cryptographic material in an elementary bitstream, where the cryptographic information can then be used to decrypt the elementary bitstream for playback

A number of embodiments include obtaining the cryptographic information, extracting the at least partially encrypted video data from the container file to create an elementary bitstream, enciphering the cryptographic information, inserting the cryptographic information in the elementary bitstream, providing the elementary bitstream to a video decoder, extracting the cryptographic information from the elementary bitstream at the video decoder, deciphering the cryptographic information, decrypting the elementary bitstream with the cryptographic information and decoding the elementary bitstream for rendering on a display device using the video decoder.

In a further embodiment, the cryptographic information is obtained from the container file.

In another embodiment, the cryptographic information includes key information and information concerning at least a portion of the at least partially encrypted video data that is encrypted using the key information.

In an additional embodiment, information concerning at least a portion of the at least partially encrypted video data is a reference to a block of encrypted data within an encoded frame of video that is encrypted using the key information.

In a still further embodiment, the cryptographic information inserted in the elementary bitstream is delimited by an identifier and the cryptographic information is inserted before the at least partially encrypted video data encrypted using the key information.

In a still other embodiment, the cryptographic information is extracted using the identifier.

US 10,212,486 B2

3

In a still additional embodiment, the decrypting process is performed by using the key information to identify the encrypted portion of video data and decrypting the encrypted video data using the key information.

In a yet further embodiment, cryptographic information inserted in different locations within the elementary bitstream includes different key information.

In a yet other embodiment, the at least partially encrypted video data includes frames of encoded video. In addition, the at least partially encrypted video data includes at least a portion of a plurality of the encoded frames that is encrypted.

In a yet further additional embodiment, the enciphering process and the deciphering process are synchronized such that a delay in excess of a predetermined time between enciphering and deciphering results in the cryptographic information being unrecoverable.

In a still further embodiment again, the enciphering process enciphers data by using a sequence of scrambling processes to scramble data.

In a still other embodiment again, the deciphering process deciphers data by performing the inverse sequence of scrambling processes to the sequence used to scramble the data.

Many embodiments include a demultiplexer configured to extract the at least partially encrypted video data from the container file to create an elementary bitstream, a video decoder configured to decrypt the elementary bitstream using the cryptographic information and decode the elementary bitstream for rendering on a display device. Additionally, the demultiplexer is configured to encipher the cryptographic information and insert the enciphered cryptographic information in the elementary bitstream and the decoder is configured to extract enciphered cryptographic information from an elementary bitstream and to decipher the cryptographic information.

In a further embodiment, the cryptographic information is obtained from the container file.

In another embodiment, the cryptographic information includes key information and information concerning at least a portion of the at least partially encrypted video data that is encrypted using the key information.

In an additional embodiment, the information concerning at least a portion of the at least partially encrypted video data is a reference to a block of encrypted data within an encoded frame of video that is encrypted using the key information.

In a further embodiment again, the demultiplexer is configured to insert the cryptographic information delimited by an identifier in the elementary bitstream and insert the cryptographic information before the at least partially encrypted video data encrypted using the key information.

In another embodiment again, the decoder is configured to extract the cryptographic information using the identifier.

In an additional embodiment again, the decoder is configured to decrypt the portion of the video data encrypted using the key information by identifying the encrypted portion of video data and decrypting the encrypted video data using the key information.

In a still further embodiment again, cryptographic information inserted in different locations within the elementary bitstream includes different key information.

In still another embodiment again, the at least partially encrypted video data includes frames of encoded video. Additionally, at least a portion of a plurality of the encoded frames is encrypted.

In a still additional embodiment, both the demultiplexer and the decoder are configured to be synchronized such that

4

a delay in excess of a predetermined time between enciphering and deciphering results in the cryptographic information being unrecoverable.

In a yet further embodiment, the demultiplexer is configured to encipher data by using a sequence of scrambling processes to scramble data.

In a yet other embodiment, the decoder is configured to decipher data by performing the inverse sequence of scrambling processes to the sequence used to scramble the data.

Numerous embodiments include obtaining the cryptographic information. In addition, the cryptographic information is obtained from the container file. Also, the at least partially encrypted video data includes frames of encoded video and at least a portion of a plurality of the encoded frames is encrypted. Additionally, the cryptographic information includes key information and information concerning at least a portion of the least partially encrypted video data that is encrypted using the key information. Furthermore, the information concerning at least a portion of the at least partially encrypted video data is a reference to a block of encrypted data within an encoded frame of video that is encrypted using the key information and the cryptographic information inserted in different locations within the elementary bitstream includes different key information.

Several embodiments include extracting the at least partially encrypted video data from the container file to create an elementary bitstream. In addition, the cryptographic information inserted in the elementary bitstream is delimited by an identifier and the cryptographic information is inserted before the at least partially encrypted video data encrypted using the key information.

Many embodiments include enciphering the cryptographic information and inserting the cryptographic information in the elementary bitstream. In addition, the cryptographic information is extracted using the identifier.

A number of embodiments include providing the elementary bitstream to a video decoder, extracting the cryptographic information from the elementary bitstream at the video decoder and deciphering the cryptographic information. In addition, the enciphering process and the deciphering process are synchronized such that a delay in excess of a predetermined time between enciphering and deciphering results in the cryptographic information being unrecoverable. Also, the enciphering process enciphers data by using a sequence of scrambling processes to scramble data. Furthermore, the deciphering process deciphers data by performing the inverse sequence of scrambling processes in the sequence used to unscramble data.

Several embodiments include decrypting the elementary bitstream with the cryptographic information. In addition, the decrypting process is performed by using the key information to identify the encrypted portion of video data and decrypting the encrypted video data using the key information.

Many embodiments include decoding the elementary bitstream for rendering on a display device using the video decoder.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a graphical representation of a multimedia container file in accordance with various embodiments of the present invention.

FIG. 2 illustrates a graphical representation of a bitstream with cryptographic material in accordance with various embodiments of the present invention.

US 10,212,486 B2

5

FIG. **3** is a block diagram of a multimedia cryptographic bitstream transport system in accordance with various embodiments of the present invention.

FIG. **4** is a flow diagram of a demultiplex and authentication process in accordance with various embodiments of the present invention.

FIG. **5** is a flow diagram of a decoder and decipher process in accordance with various embodiments of the present invention.

FIG. **6** is a block diagram of a multimedia cryptographic bitstream transport system in accordance with various embodiments of the present invention.

FIG. **7** is a flow diagram of a wrap key generation process in accordance with various embodiments of the present invention.

FIG. **8** is a flow diagram of a bitstream insertion process in accordance with various embodiments of the present invention.

DETAILED DESCRIPTION

Systems and methods for providing multimedia content from one process or component to another process or component over an unsecured connection are provided. In several embodiments, the transmission occurs between a demultiplexer and a decoder over an unsecured connection where traditionally such connections are secured. In many embodiments, the transmission occurs on a bi-directional communication path. Embodiments of the present invention do not secure the transmission but rather secure the data being transmitted via the unsecured connection. The transmitted data in a number of embodiments includes an encrypted multimedia bitstream and associated cryptographic material in the bitstream for transmission to a decoder for decryption. In various embodiments, a bi-directional communication path between a demultiplexer and the decoder is not used. Additionally, by allowing the decryption to occur on the decoder the bitstream is protected even if the connection is compromised and an unauthorized component or process intercepts the bitstream.

In various embodiments, frame keys are used to decrypt the bitstream. For example, in the manner described in U.S. Pat. No. 7,295,673 to Grab et al. the disclosure of which is incorporated by reference herein in its entirety. In several embodiments, the frame keys are protected by a cryptographic wrap algorithm that uses a separate series of newly generated keys. The wrapped frame keys are inserted into the encrypted bit stream for deciphering and decoding by the decoder. The cryptographic information in various embodiments includes information to decrypt a video frame or a portion of the video frame. In various embodiments, a time indicator in the form of a frame sequence is also utilized to ensure connection between the demultiplexer and decoder is not being intercepted or spied upon.

The cryptographic information inserted into the elementary bitstream can take any of a variety of forms. In many embodiments, the cryptographic information includes a frame key and/or a reference to a block of encrypted video data. In several embodiments, the cryptographic information contains an index to a frame key or a separate reference to both a frame key and an encrypted block. A number of embodiments provide for first inserting a table of possible keys and still further embodiments provide for sending multiple keys where different keys are used to encrypt different portions of the video.

Turning now to the drawings, FIG. **1** represents a multimedia container file **20** including encrypted content, e.g.,

6

video. The multimedia container file includes a digital rights management portion **21** preceding associated video portions or chunks **22**. The digital rights management portion includes at least one frame key **23** or an index to a frame key in a separately provided table of frame keys, which in many embodiments is encrypted in a way that only enables playback by a particular device and/or user. The digital rights management portion also points to or identifies a specified portion of or an entire video frame within the video chunk **24** that is encrypted. Without first decrypting this encrypted portion of the video chunk, the video content cannot be decoded or displayed. The multimedia container file is supplied to a demultiplexer.

The demultiplexer parses the multimedia container file and transmits portions or chunks of data, e.g., video or audio, to a decoder. However, prior to transmitting the video data, the demultiplexer incorporates or attaches cryptographic material to the video data.

FIG. **2** graphically illustrates the generated multimedia bitstream sent to the decoder. The bitstream **30** includes a header or user data **31** that includes cryptographic material **32**. In accordance with many embodiments of the invention, the material includes the frame key **23** from the multimedia container file, which is encrypted using a wrap key, and wrap key information **34** to provide synchronization of the demultiplexer to the decoder in order to decipher the cryptographic material. As is discussed below, the wrap key information can take any of a variety of different forms depending upon the specific application including but not limited to information enabling synchronization of wrap key factories and/or the direct transfer of the wrap keys themselves. The associated video data **33** follows.

Referring now to FIG. **3**, a demultiplexer **10** that receives a multimedia container file that includes video and audio data, portions of which are encrypted, is shown. In one embodiment, the multimedia file conforms to a specific format such as audio video interleave (AVI) or Matroska (MKV). The multimedia file is provided via a disc, flash memory device or another tangible storage medium or streamed or otherwise transmitted to the demultiplexer. The demultiplexer separates portions of the received multimedia data including but not limited to video, audio and encryption data that is supplied to an upstream digital rights management component **15**. In various embodiments, the connection between the demultiplexer **10** and the digital rights management component **15** can be secure although need not be depending upon the requirements of the application. The digital rights management component **15** generates cryptographic material and the multimedia bitstream transport that is supplied to a decoder **20**. In particular, the demultiplexer **10** transmits video data with cryptographic material to the decoder **20**.

The connection between the demultiplexer and the decoder is typically secured. However, in the illustrated embodiment, the connection is not secured. Typically, the multimedia file is authorized and decrypted in a demultiplexer and then transmitted downstream unencrypted to the decoder via an inter-communication data channel. This however can present a security problem due to the high value of the unencrypted but still encoded bitstream that can be captured during transmission. This bitstream is considered high-value since the encoded data can be easily multiplexed back into a container for unprotected and unauthorized views and/or distribution with no loss in the quality of the data. In the illustrated embodiment, the video provided to the decoder **20** by the demultiplexer **10** is at least partially encrypted and the decoder **20** communicates with a down-

US 10,212,486 B2

7   8

stream digital rights management component **25** that deciphers the cryptographic material. Utilizing the deciphered cryptographic material, the digital rights management component is able to access the encryption data and thereby decrypt and decode the video data for playback.

The general processes of the demultiplexer and the decoder are now described. In FIG. **4**, the demultiplexer and authentication process is illustrated in which a multimedia container file is received and portions of which are identified or separated (**101**). If encryption data is identified, cryptographic packets or material are generated (**102**) and stored in a temporary buffer (**103**). However, if video data is identified (**104**), the cryptographic material stored in the temporary buffer is combined with the video data (**105**) and then transmitted to a video decoder (**106**). If audio data is identified (**107**), the audio data is transmitted (**108**) to the audio decoder. It should be appreciated that audio or other types of data may also include encryption data and thus associated cryptographic material is generated and combined with the associated data and transmitted to the respective decoder. Also, other types of data may be included in the container file without encryption data and thus is transmitted directly to the associated decoder.

In FIG. **5**, a decoder and decipher process is illustrated in which the decoder receives video and/or audio data sent from the demultiplexer (**201**). The decoder deciphers the cryptographic material supplied with the associated data (**202**). Utilizing the deciphered material, the encrypted data is decrypted (**203**) and decoded (**204**) by the decoder for playback.

To further elaborate on the demultiplexer and decoder processes and the bitstream transport system, a more detailed representation of the demultiplexer's and decoder's associated digital rights manager along with the associated processes are illustrated in the remaining figures.

Referring to FIG. **6**, the upstream digital rights manager **15** of the demultiplexer **10** includes an authentication engine **16**, a bit stream inserter **17**, a payload builder **18** and a wrap key factory **19**. The downstream digital rights manager **25** of the decoder includes a decrypt engine **26**, a bit stream decoder **27**, a payload parser **28** and a wrap key factory **29**. The authentication engine prepares cryptographic material utilizing the encryption data from the container file and the video data in conjunction with the payload builder **18** and the wrap key factory **19**.

The payload builder **18** provides discrete units of cryptographic material in the bitstream delimited by an identifier. On the decoder, the payload parser **28** utilizes the identifiers to extract the discrete units, which are then processed by the decrypt engine **26**. In many embodiments, the cryptographic material in one embodiment includes a bitstream frame header along with a cryptographic payload. The cryptographic payload, however, is not dependent on the format of the header of the elementary bitstream, e.g., MPEG-4 or H.264.

In one embodiment, the payload builder **18** inserts a reserved start code identifier along with a cryptographic payload at the front of each video chunk that is demultiplexed. By utilizing a reserved start code, the decrypt engine **26** can pass the entire video data including the inserted cryptographic material to the decoder **20** that simply discards or ignores the cryptographic material. For example, a MPEG-4 compliant decoder discards frames that contain a reserved start code identifier that is included in the bitstream. Accordingly, removal of any of the cryptographic material from the bitstream is not needed to decode the associated data.

The cryptographic payload in one embodiment includes three different packet types: a wrap key, a synchronization payload and a frame payload. The frame payload indicates that the current frame is encrypted and includes key information and a reference to at least a portion of the encoded frame that is encrypted. The frame payload can be used to decrypt the video frame. The synchronization payload is the first packet sent to synchronize the authentication engine of the demultiplexer to the decrypt engine of the decoder. This synchronization ensures that data transmitted from the demultiplexer to the decoder is not being intercepted. The wrap key includes information to unwrap or decipher the transmitted data from the demultiplexer.

The bit stream inserter **17** packages the cryptographic material for transport with the video data. Conversely, the bit stream decoder **27** of the decoder unpacks the cryptographic material from the bitstream. In one embodiment, frame keys are transported in the bitstream and are sent when a key index change is detected by the authentication engine of the demultiplexer. In many embodiments, the decrypt engine of the decoder stores only one frame key and thus frame encryption information sent by the demultiplexer applies to the current frame. If the decrypt engine receives a new frame key from the demultiplexer, the decrypt engine stores the new frame key and uses it to decrypt the next frame. In a number of embodiments, a key table is transmitted and stored in the decrypt engine for reference by subsequent encryption information. In several embodiments, the decoder does not enforce key rotation. In many embodiments, however, the decoder expects a new frame key after a predetermined number of frames in the sequence of frames. In this way, the decrypt engine can identify when supplied frame information is unreliable and terminate the decoding of the multimedia bitstream.

The wrap key factory **19** encrypts or wraps the cryptographic material for transport on the bitstream to the decoder. In one embodiment, the wrap key factory uses a key wrap process based on the Advanced Encryption Standard (AES) and uses the ECB Cipher Mode to provide cryptographic security for wrapping small blocks of data using chaining and cipher feedback loop. The key wrap process is stateless. A corresponding wrap key factory is included with the decoder to unwrap the cryptographic material. Synchronization with the corresponding wrap key factory **29** is used to allow unwrapping of the material without communication back to the demultiplexer (i.e., bi-directional communication) and to prevent unauthorized decoding of the content by, for example, a rogue process intercepting or copying the transmitted content.

Wrap Key Factory

In one embodiment, each of the authentication and decryption blocks (digital rights managers **15**, **25**) construct a series of predictable transform number sequences using a common heuristic. Subsequently, those numbers are combined with a random value for additional entropy used to contribute toward key material for wrapping keys.

A flow diagram of a wrap key generation process **300** in accordance with an embodiment of the invention is illustrated in FIG. **7**. A selected heuristic (**302**) is combined with key material (**304**) to create a wrap key (**306**).

In accordance with various embodiments, one such heuristic (**302**) may combine the use of a predictable number sequence generator such that identical transform sequences can be generated by different heuristics even though no information is exchanged. If both authentication and decrypt blocks are created such that the output of the common heuristic are identical, the key material (**304**) generated from

US 10,212,486 B2

9 10

such heuristic will be identical. This may apply in situations where a wrapped key (**306**) and a selected heuristic (**302**) are provided. Any process for generating identical encryption keys without exchange of key material can be used as an appropriate heuristic to generate wrapping keys (**306**) in accordance with embodiments of the invention. Although, some information exchange to enable synchronization between the two wrap key factories can be utilized in accordance with embodiments of the invention.

The two wrap key factories use the same transform sequence. To synchronize the wrap key factories, the sender's wrap key factory selects one heuristic (**302**) from a predetermined set of heuristics to generate the key material for the next wrap key. The decoder factory will receive a known payload that has been encrypted with the sender's wrap key (**306**) generated using selected heuristic (**302**) from the known set of heuristics. The receiver then attempts to decrypt and verify the contents of the payload using each of the predetermined heuristics. If the material matches what is expected, then the receiver has identified the correct heuristic (**302**). If all the heuristics are exhausted, then this is considered a fatal error and decryption cannot continue.

Initially, the synchronization payload is used to assist the decrypt block in identifying the appropriate transform sequence quickly. Once the decrypt block locates the proper heuristic (**302**), the decrypt block wrap key factory utilizes that transform sequence for all subsequent transforms. In several embodiments, once a heuristic has exhausted all values, that heuristic will deterministically choose the next heuristic to use.

Run time synchronization is maintained through monotonically incrementing a wrap number that is incremented for each wrap key generated. If an error occurs using a particular wrap key (i.e. unallowable data present in the cryptographic payload), the wrap key factory will regenerate a new wrap key and subsequently increment the wrap number. In one embodiment, the frame payload received by the decrypt block contains a wrap number element. On the decrypt block, this wrap number element is compared with the internal wrap number of the decrypt block to determine if the current wrap key needs to be skipped. In one embodiment, the wrap key includes data fed into a cryptographic digest. The resulting bytes from the digest are then used to create an AES key. A new wrap key will be generated for each payload that is wrapped.

Bitstream Data Insertion

A flow diagram of a bitstream insertion process **400** utilized with respect to video data extracted from an AVI container in accordance with an embodiment of the invention is illustrated in FIG. **8**. In the demultiplexer, a caller begins extraction (**402**) of a relevant AVI chunk and requests (**404**) the DRM for the maximum expected bitstream payload. The demultiplexer then uses the information from the DRM to allocate (**406**) space in a buffer and passes (**408**) the buffer to the DRM. Next on the DRM, the video DD info is cached (**410**). The video DD info may be a data segment in a file container describing the data contained in a single block of container data, such as all of the video frame data in a single AVI chunk. Encrypted frames may have a DD info which contains information relating to the security features of the frame. The MPEG4 reserved start code is inserted (**412**) into the buffer and then the cryptographic payload header is inserted (**414**) into the buffer. A decision (**416**) is then made as to whether the chunk is the first frame. If the chunk is the first frame, then a Sync( ) payload is inserted (**418**) and a FrameInfo( ) payload is inserted (**420**). The Sync( ) payload may include the wrap key synchroni-

zation payload to synchronize the wrap keys. The FrameInfo( ) payload may include the cryptographic offset and length of information relating to data security in the video data, possibly as part of the DD Info data. If the chunk is not the first frame, then only the FrameInfo( ) payload is inserted (**420**). Then, a decision (**422**) is made as to whether the key index is greater than the current key index. If the key index is greater than the current key index, a FrameKey( ) payload is inserted (**424**) in the buffer and then the number of bytes inserted into the buffer is returned (**426**) to the caller by the DRM. The FrameKey( ) payload may include the payload containing the next frame key. If the key index is not lower than the current key index, then the DRM returns (**426**) the number of bytes inserted in the buffer to the caller. Next, the demultiplexer, is ready to extract (**428**) the AVI chunk. Through this process, DD info awareness occurs before the demultiplexer extracts the video chunk into the buffer for transmission to the decoder.

In various embodiments, bitstream data insertion occurs in the authentication block of the demultiplexer. The digital rights manager in one embodiment first receives the container's encryption data and temporarily stores or caches the information. The cached encryption data contains the information for the next video chunk. From this information, the digital rights manager can determine the proper bitstream payload to insert, if any. To reduce memory copies, the digital rights manager inserts the bitstream payload before extracting the chunk from the container.

Based on the cached encryption data chunk, the digital rights manager can detect frame key changes. If the frame key index has not changed since the last cached encryption data, no key material is sent. In one embodiment, the encryption data is always transported if there is cached encryption data in the digital rights manager. On the first payload, there will be a synchronization payload to allow the decrypt block to synchronize the wrap sequence. The frame information payloads in one embodiment follow the synchronization payload. It should be appreciated that not all payloads are required to appear in each decrypt block. Furthermore, the processes similar to those described above with reference to FIG. **8** can also be used with respect to other container formats including but not limited to MKV container files.

Although the present invention has been described in certain specific aspects, many additional modifications and variations would be apparent to those skilled in the art. It is therefore to be understood that the present invention may be practiced otherwise than specifically described, including various changes in the size, shape and materials, without departing from the scope and spirit of the present invention. Thus, embodiments of the present invention should be considered in all respects as illustrative and not restrictive.

What is claimed is:

1. A playback device for playing back encrypted video, the playback device comprising:
   a set of one or more processors; and
   a non-volatile storage containing a playback application for causing the set of one or more processors to perform the steps of:
      receiving a container file with video data at a parser;
      extracting portions of the container file using the parser, wherein the container file comprises:
         video data with a plurality of partially encrypted frames, wherein each partially encrypted frame contains encrypted portions and unencrypted portions of data; and

US 10,212,486 B2

11

a set of cryptographic information describing the encrypted portion of each partially encrypted frame, where cryptographic information for a partially encrypted frame comprises:

cryptographic material for the encrypted portion of the partially encrypted frame, and

a block reference that identifies the encrypted portion of the partially encrypted frame,

providing each partially encrypted frame, the cryptographic material for each partially encrypted frame, and the block reference for each partially encrypted frame from the parser to a video decoder;

identifying the encrypted portion of each partially encrypted frame using the block reference for each partially encrypted frame;

deciphering a frame key for each partially encrypted frame using the cryptographic material for each partially encrypted frame to produce a frame key for each partially encrypted frame;

decrypting the encrypted portion of each partially encrypted frame based upon the frame key for each partially encrypted frame using the video decoder; and

decoding each decrypted frame for rendering on a display device using the video decoder.

2. The playback device of claim 1, wherein each partially encrypted frame is provided by the parser to a video decoder over an unsecured channel.

3. The playback device of claim 1, wherein each block reference comprises offset and length information.

4. The playback device of claim 1, wherein the playback application is further for causing the set of processors to communicate with a digital rights management component to decipher a frame key for each partially encrypted frame from the cryptographic material for each partially encrypted frame.

5. The playback device of claim 1, wherein the frame key is encrypted to restrict playback to a particular user.

6. The playback device of claim 1, wherein the frame key is encrypted to restrict playback to a particular user.

7. The playback device of claim 1, wherein the playback application is further for causing the set of one or more processors to stream the container file.

8. The playback device of claim 1, wherein:

the playback application is further for causing the set of one or more processors to perform the step of providing each partially encrypted frame, the cryptographic material for each partially encrypted frame, and the block reference for each partially encrypted frame from the parser to a video decoder by building a cryptographic payload comprising:

cryptographic material for a partially encrypted frame, and

a block reference for the partially encrypted frame.

9. The playback device of claim 8, wherein the cryptographic payload is delimited by an identifier.

10. The playback device of claim 9, wherein the decoder uses the identifier to extract cryptographic material for the partially encrypted frame and the block reference for the partially encrypted frame from the cryptographic payload.

11. The playback device of claim 1, wherein the playback application is further for causing the set of one or more processors to perform the step of inserting the cryptographic payload at the front of each partially encrypted frame of video that is demultiplexed by the parser.

12

12. The playback device of claim 1, further comprising inserting the cryptographic payload at the front of each partially encrypted frame of video using the parser.

13. The playback device of claim 1, an encrypted portion of a partially encrypted frame comprises a frame header.

14. The playback device of claim 1, wherein an unencrypted portion of a partially encrypted frame comprises a frame header.

15. A method for playing back encrypted video, the method comprising:

receiving a container file with video data at a parser;

extracting portions of the container file using the parser, wherein the container file comprises:

video data with a plurality of partially encrypted frames, wherein each partially encrypted frame contains encrypted portions and unencrypted portions of data; and

a set of cryptographic information describing the encrypted portion of each partially encrypted frame, where cryptographic information for a partially encrypted frame comprises:

cryptographic material for the encrypted portion of the partially encrypted frame, and

a block reference that identifies the encrypted portion of the partially encrypted frame,

providing each partially encrypted frame, the cryptographic material for each partially encrypted frame, and the block reference for each partially encrypted frame from the parser to a video decoder;

identifying the encrypted portion of each partially encrypted frame using the block reference for each partially encrypted frame;

deciphering a frame key for each partially encrypted frame using the cryptographic material for each partially encrypted frame to produce a frame key for each partially encrypted frame;

decrypting the encrypted portion of each partially encrypted frame based upon the frame key for each partially encrypted frame using the video decoder; and

decoding each decrypted frame for rendering on a display device using the video decoder.

16. The method of claim 15, wherein each partially encrypted frame is provided by the parser to a video decoder over an unsecured channel.

17. The method of claim 15, wherein each block reference comprises offset and length information.

18. The method of claim 15 further comprising communicating with a digital rights management component to decipher a frame key for each partially encrypted frame from the cryptographic material for each partially encrypted frame.

19. The method of claim 15, wherein the frame key is encrypted to restrict playback to a particular user.

20. The method of claim 15, wherein the frame key is encrypted to restrict playback to a particular user.

21. The method of claim 15, wherein providing each partially encrypted frame, the cryptographic material for each partially encrypted frame, and the block reference for each partially encrypted frame from the parser to a video decoder further comprises building a cryptographic payload comprising:

cryptographic material for a partially encrypted frame, and

a block reference for the partially encrypted frame.

22. The method of claim 21, wherein the cryptographic payload is delimited by an identifier.

US 10,212,486 B2

13   **14**

23. The method of claim **22**, further comprising extracting cryptographic material for the partially encrypted frame and the block reference for the partially encrypted frame from the cryptographic payload based upon the identifier using the video decoder.

24. The method of claim **15**, wherein an encrypted portion of a partially encrypted frame comprises a frame header.

25. The method of claim **15**, wherein an unencrypted portion of a partially encrypted frame comprises a frame header.

* * * * *

US010412141B2

(12) **United States Patent**
Osborne

(10) **Patent No.:**   **US 10,412,141 B2**
(45) **Date of Patent:**   **Sep. 10, 2019**

(54) **SYSTEMS AND METHODS FOR SEEKING WITHIN MULTIMEDIA CONTENT DURING STREAMING PLAYBACK**

(71) Applicant: **DIVX, LLC**, San Diego, CA (US)

(72) Inventor: **Roland Osborne**, San Francisco, CA (US)

(73) Assignee: **DIVX, LLC**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/136,149**

(22) Filed: **Sep. 19, 2018**

(65) **Prior Publication Data**

US 2019/0020704 A1   Jan. 17, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/682,379, filed on Aug. 21, 2017, which is a continuation of application
(Continued)

(51) **Int. Cl.**
G06F 16/71   (2019.01)
H04L 29/06   (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC *H04L 65/604* (2013.01); *G06F 16/71* (2019.01); *G06F 16/739* (2019.01);
(Continued)

(58) **Field of Classification Search**
CPC G06F 17/30; H04L 65/40; H04N 5/76
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,742,082 B1   5/2004 Lango et al.
7,664,872 B2   2/2010 Osborne et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CA   2306524 A1   9/2001
CN   1575595 A   2/2005
(Continued)

OTHER PUBLICATIONS

Adobe—Development Center: Flash video learning guide, printed Jan. 13, 2009 from http://www.adobe.com/devnet/flash/articles/video_guide_02.html, 5 pgs.
(Continued)

Primary Examiner — Glenford J Madamba
(74) *Attorney, Agent, or Firm* — KPPB LLP

(57)   **ABSTRACT**

A receiver driven approach for playback of remote content is described. One embodiment includes obtaining information concerning the content of the media file from the remote server, identifying a starting location within the media sequence, identifying byte ranges of the media file corresponding to media required to play the media sequence from the starting location, requesting the byte ranges required to play the media sequence from the starting location, buffering received bytes of information pending commencement of playback, playing back the buffered bytes of information, receiving a user instruction, identifying byte ranges of the media file corresponding to media required to play the media sequence in accordance with the user instruction, flushing previous byte range requests, and requesting the byte ranges required to play the media in accordance with the user instruction.

30 Claims, 9 Drawing Sheets

Appx46
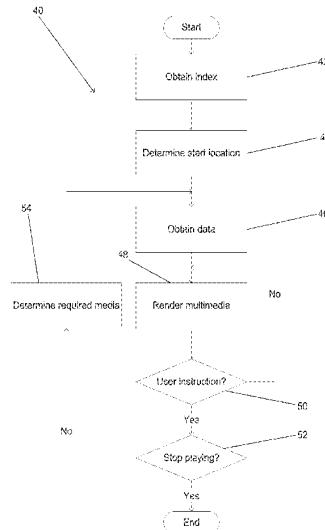
US 10,412,141 B2

Page 2

Related U.S. Application Data

No. 14/632,670, filed on Feb. 26, 2015, now Pat. No. 9,794,318, which is a continuation of application No. 12/982,413, filed on Dec. 30, 2010, now Pat. No. 8,977,768, which is a continuation of application No. 11/970,493, filed on Jan. 7, 2008, now Pat. No. 7,886,069.

(60) Provisional application No. 60/883,659, filed on Jan. 5, 2007.

(51) **Int. Cl.**

G06F 16/738	(2019.01)
H04N 5/76	(2006.01)
H04N 5/783	(2006.01)
H04N 7/173	(2011.01)
H04N 21/234	(2011.01)
H04N 21/44	(2011.01)
H04N 21/472	(2011.01)
H04N 21/6587	(2011.01)

(52) **U.S. Cl.**
CPC *H04L 65/4084* (2013.01); *H04L 65/4092* (2013.01); *H04N 5/76* (2013.01); *H04N 5/783* (2013.01); *H04N 7/17318* (2013.01); *H04N 21/23406* (2013.01); *H04N 21/44004* (2013.01); *H04N 21/472* (2013.01); *H04N 21/6587* (2013.01)

(58) **Field of Classification Search**
USPC 709/100
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,734,806 B2	6/2010	Park	
7,886,069 B2	2/2011	Osborne	
7,895,311 B1	2/2011	Juenger	
8,731,369 B2	5/2014	Li et al.	
8,977,768 B2	3/2015	Osborne	
9,794,318 B2	10/2017	Osborne	
2002/0161797 A1*	10/2002	Gallo G06F 17/30905 715/203
2003/0077071 A1	4/2003	Lin et al.	
2003/0169815 A1*	9/2003	Aggarwal G06T 9/004 375/240.12
2005/0102371 A1	5/2005	Aksu	
2005/0207442 A1*	9/2005	Zoest G11B 20/00086 370/465
2006/0037057 A1	2/2006	Xu	
2006/0059223 A1	3/2006	Klemets et al.	
2006/0093318 A1	5/2006	Cohen et al.	
2006/0129909 A1	6/2006	Butt et al.	
2006/0161635 A1	7/2006	Lamkin et al.	
2006/0168291 A1	7/2006	Van Zoest et al.	
2006/0174021 A1	8/2006	Osborne et al.	
2006/0174026 A1	8/2006	Robinson et al.	
2006/0195884 A1	8/2006	Van Zoest et al.	
2006/0200744 A1	9/2006	Bourke et al.	
2006/0294212 A1	12/2006	Kikkawa et al.	
2007/0083663 A1	4/2007	Tanabe et al.	
2007/0106863 A1	5/2007	Bonwick et al.	
2007/0157267 A1	7/2007	Lopez-Estrada	
2007/0162568 A1*	7/2007	Gupta G06Q 30/0242 709/219

2007/0209005 A1	9/2007	Shaver et al.	
2007/0220118 A1	9/2007	Loyer	
2008/0022005 A1	1/2008	Wu et al.	
2008/0071838 A1	3/2008	Moriya et al.	
2008/0082576 A1	4/2008	Bodin et al.	
2008/0168133 A1	7/2008	Osborne	
2008/0177793 A1	7/2008	Epstein et al.	
2009/0067367 A1	3/2009	Buracchini et al.	
2010/0198943 A1	8/2010	Harrang et al.	
2011/0099225 A1	4/2011	Osborne	
2015/0172351 A1	6/2015	Osborne	
2017/0353520 A1	12/2017	Osborne	

FOREIGN PATENT DOCUMENTS

CN	1581971 A	2/2005		
CN	1596403 A	3/2005		
CN	1801929 A	7/2006		
CN	101636726 A	1/2010		
CN	101636726 B	10/2013		
CN	103559165 A	2/2014		
CN	103561278 A	2/2014		
CN	103559165 B	8/2016		
CN	103561278 B	4/2017		
EP	1534013 A1	5/2005		
EP	2122482 A1	11/2009		
EP	2122482 B1	11/2018		
EP	3467666 A1	4/2019		
JP	2003504984	2/2003		
JP	2003111048	4/2003		
JP	2003111048 A	4/2003		
JP	2004295568	10/2004		
JP	2004362099	12/2004		
JP	2005149029	6/2005		
JP	2005518726	6/2005		
JP	2005341334 A	12/2005		
JP	2006074511 A	3/2006		
JP	2010516123 A	5/2010		
WO	2001006788 A1	1/2001		
WO	2003046750	6/2003		
WO	WO-03046750 A1 *	6/2003	....	H04L 29/06027
WO	2003071800 A1	8/2003		
WO	2003088665 A1	10/2003		
WO	2005057906 A2	6/2005		
WO	2006045334 A1	5/2006		
WO	2008086313 A1	7/2008		

OTHER PUBLICATIONS

International Preliminary Report on Patentability for International Application No. PCT/US2008/050440, Report Completed Aug. 7, 2009, dated Aug. 11, 2009, 8 pgs.

International Search Report for International Application No. PCT/US2008/050440, International Filing Date Jan. 7, 2008, Search completed Apr. 23, 2008, dated May 16, 2008, 2 pgs.

RedOrbit News, New DivX Web Player Hits 1 Milling Downloads in One Week, printed Jan. 13, 2009 from http://www.redorbit.com/modules/news/tools.php?tool=print&id=421307, 2 pgs.

Vuze HD Network, printed Jun. 1, 2009 from http://www.vuze.com/Index.html, 1 pg.

Written Opinion of international Application No. PCT/US2008/050440; International filed Jan. 7, 2008, Opinion completed Apr. 23, 2008, dated May 16, 2008, 9 pgs.

Fielding et al., "Hypertext Transfer Protocol—HTTP1.1", Network Working Group, RFC 2616, Jun. 1999, 114 pgs.

Extended European Search Report for European Application No. 18206048.3, Search completed Feb. 8, 2019 , dated Feb. 21, 2019, 11 Pgs.

* cited by examiner

FIG. 1

FIG. 2

60

Playback Engine	64
File Parser	66
Download Manager	62

FIG. 3

FIG. 4

FIG. 5

FIG. 6

FIG. 7

FIG. 8

190

```
        ( Start )
            |
            v
  +---------------------+
  |  Index Extraction   |————192
  +---------------------+
            |
            v
  +---------------------+
  | Data block selection |————194
  +---------------------+
            |
            v
  +---------------------+
  |  Download data block |————196
  +---------------------+
            |
            v
  +---------------------+
  |  Playback data block |————198
  +---------------------+
            |
            v
        (  End  )
```
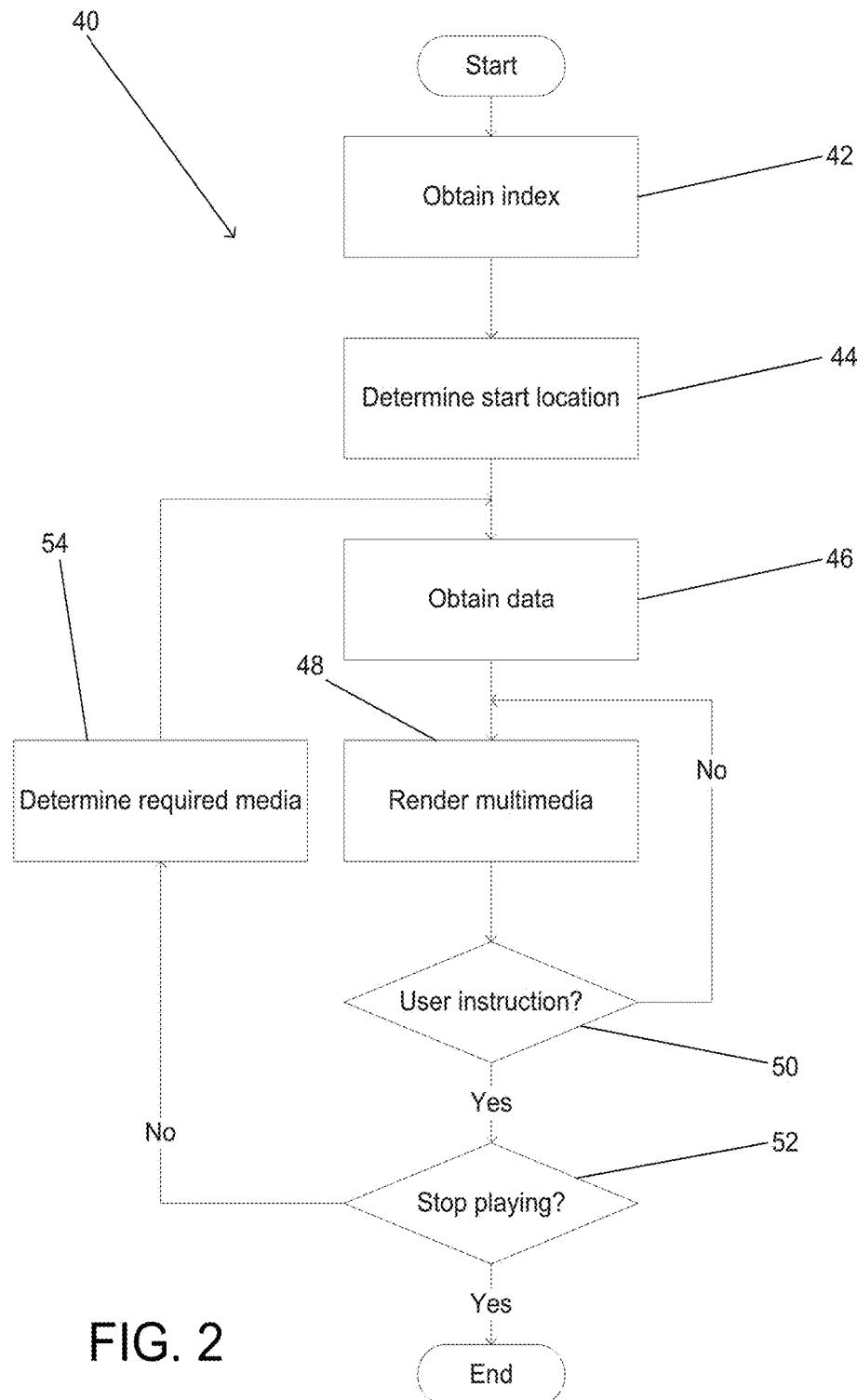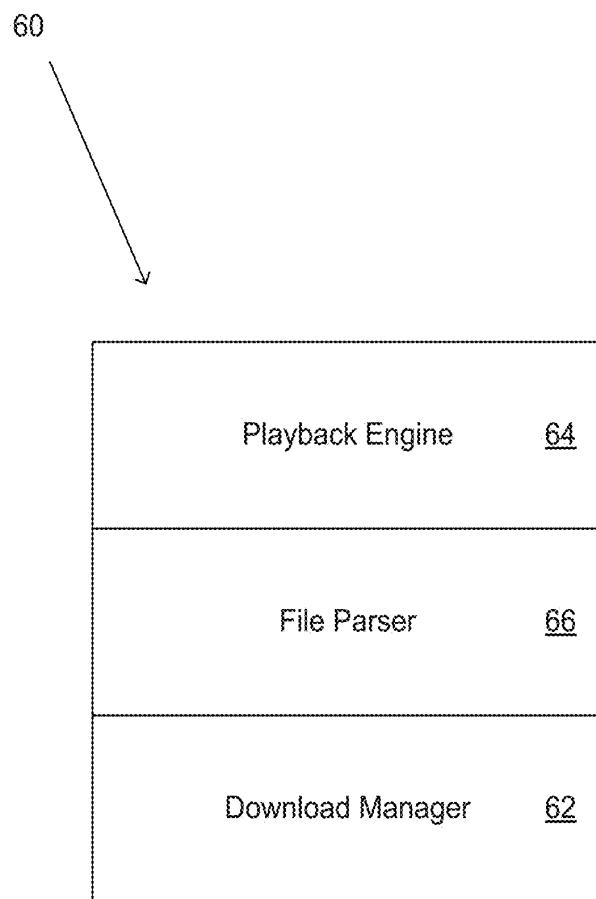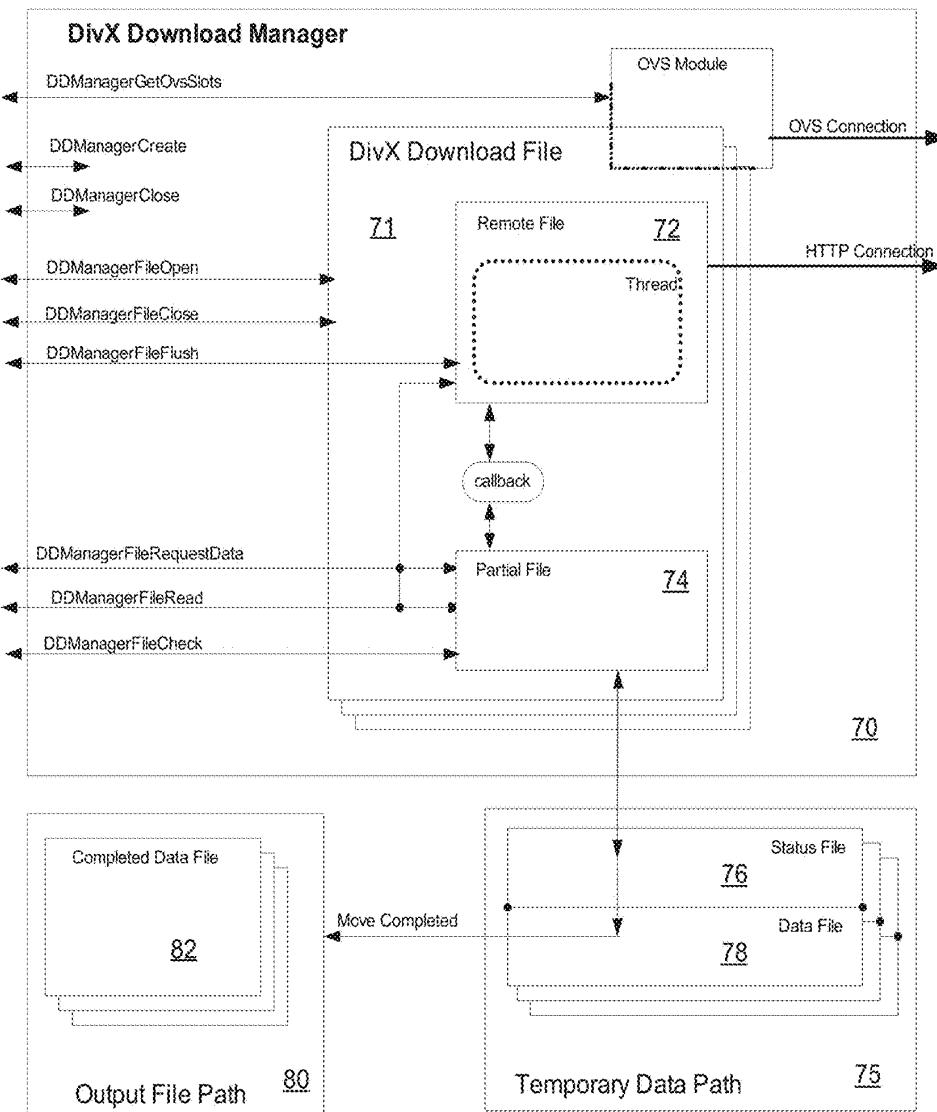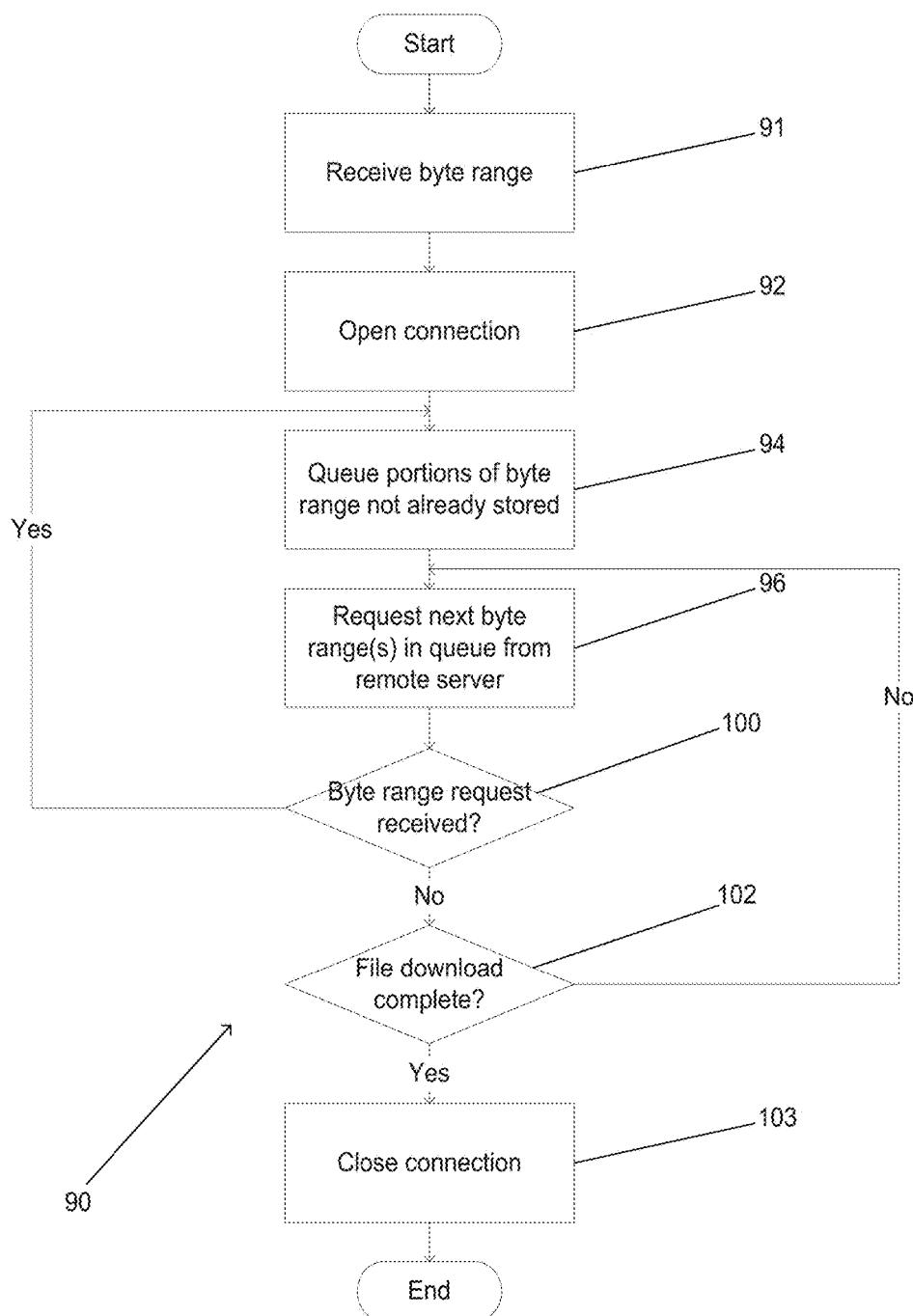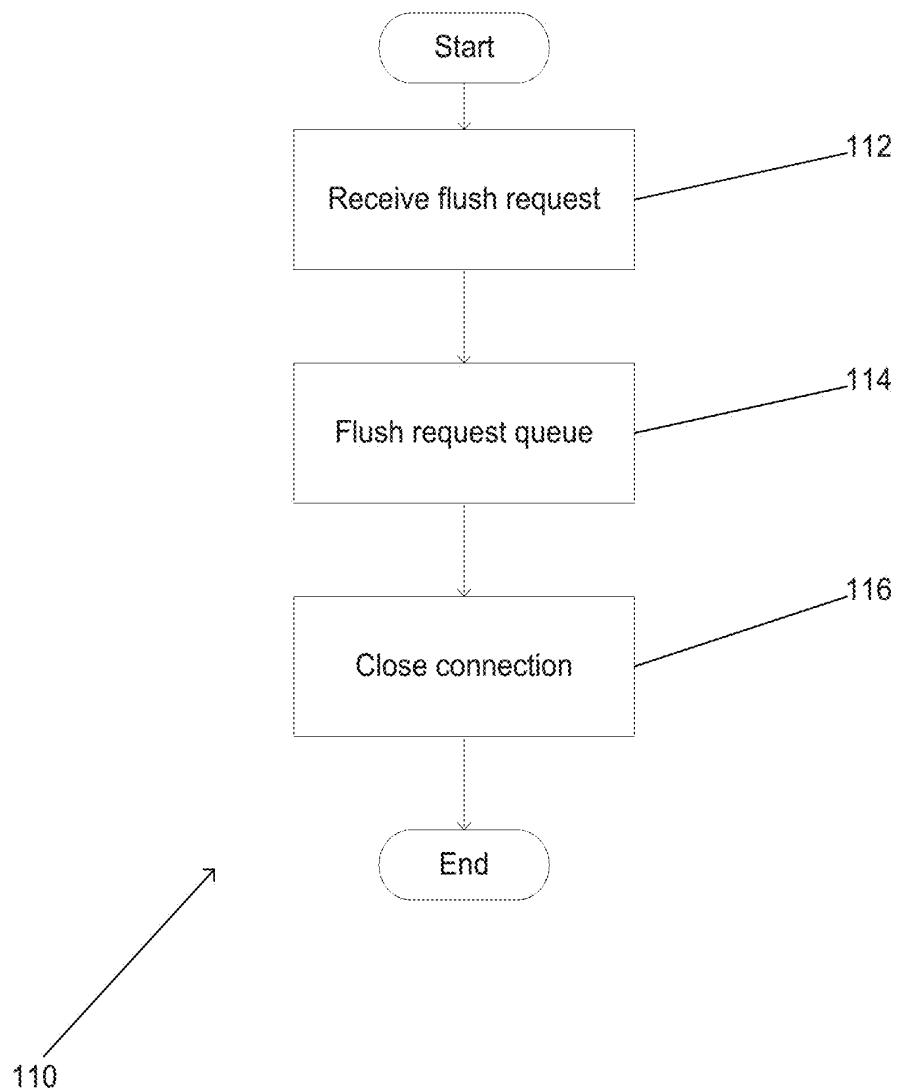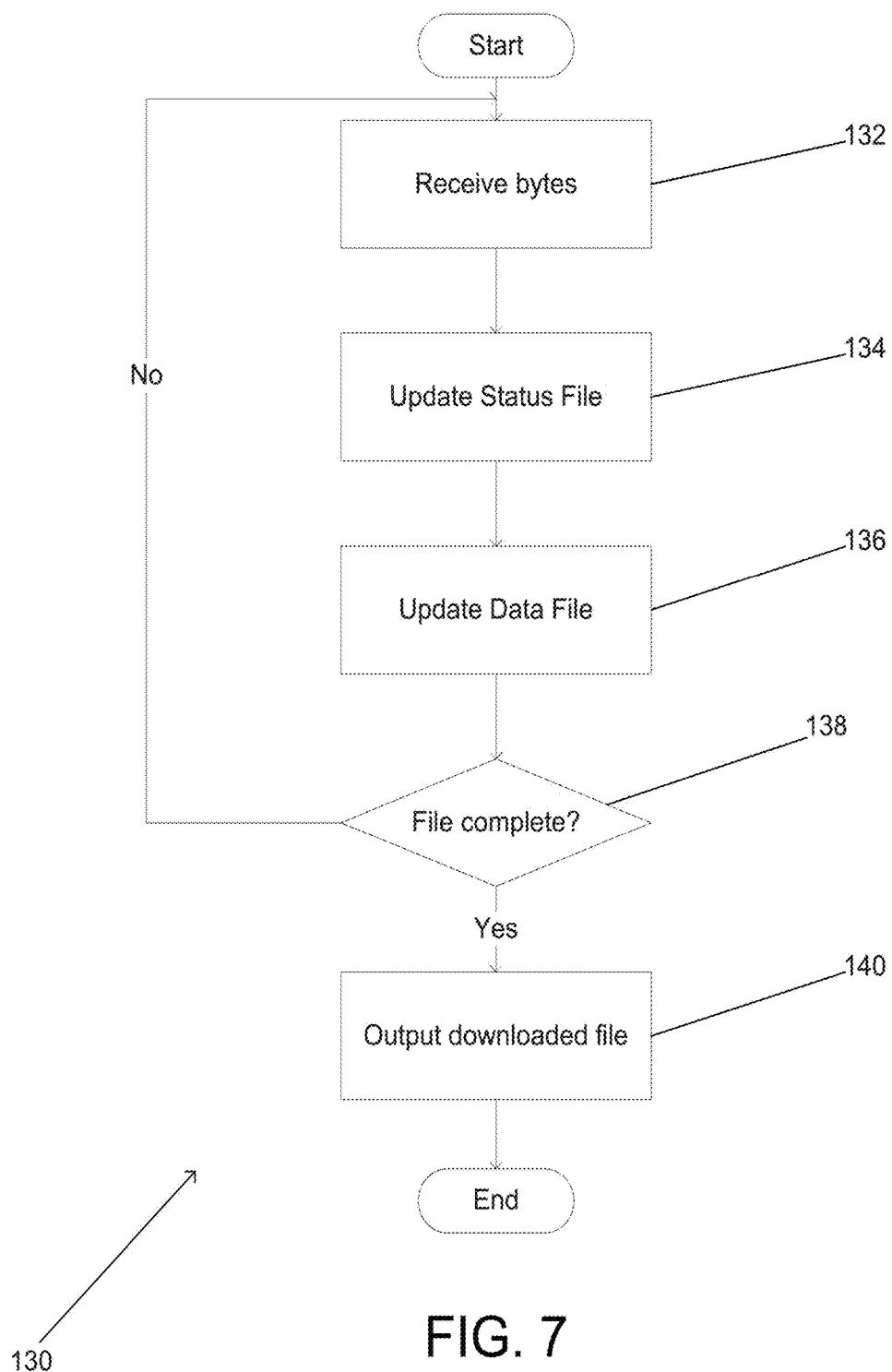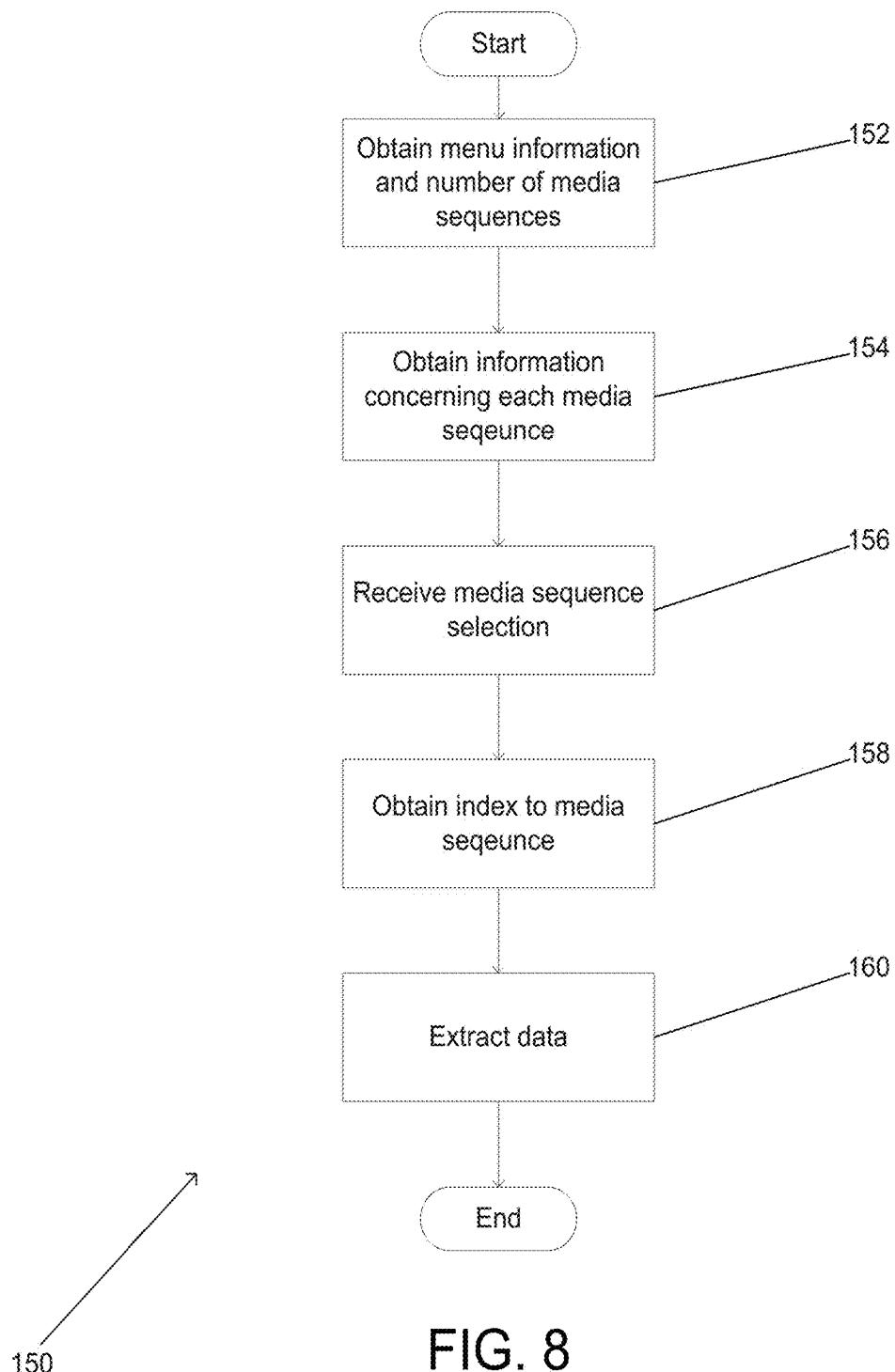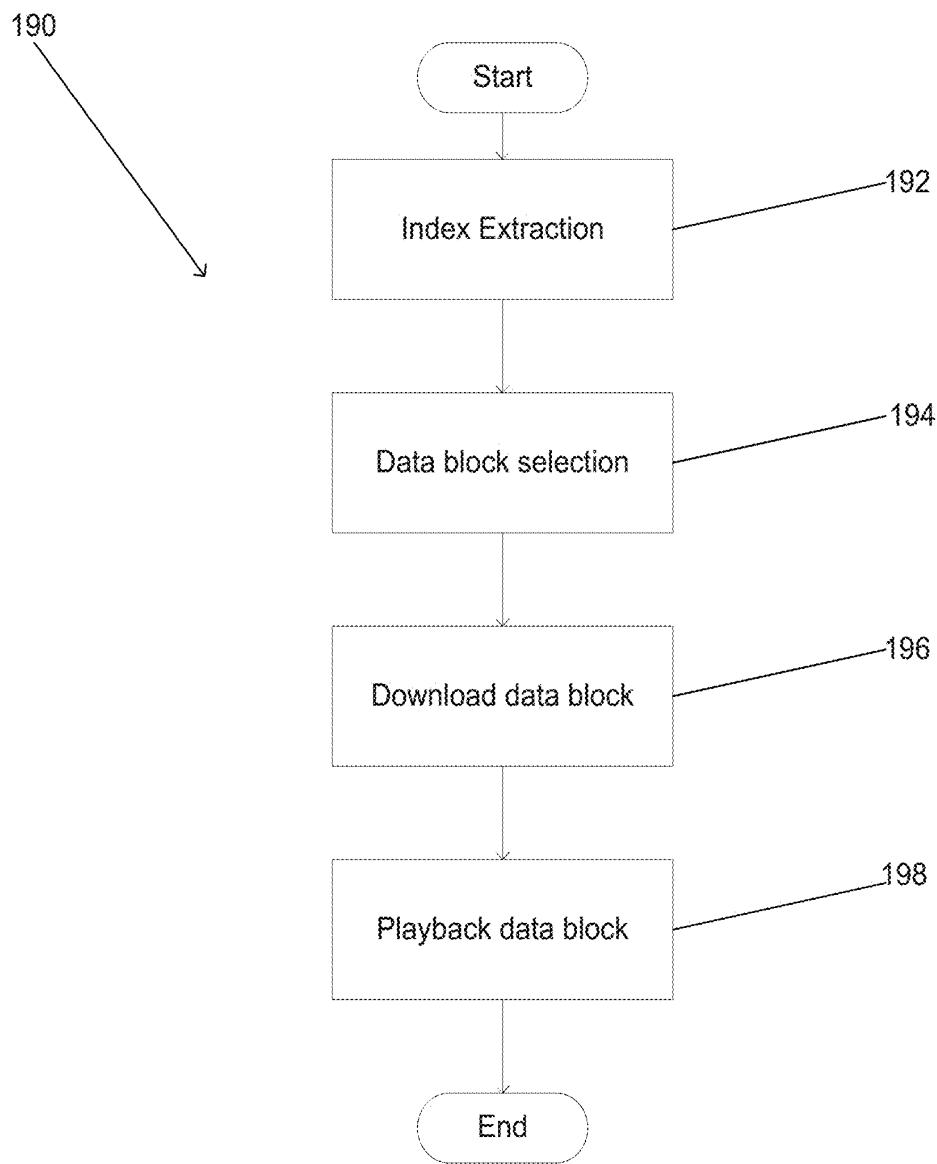
FIG. 9

US 10,412,141 B2

<table>
<tr><td>1</td><td>2</td></tr>
</table>

SYSTEMS AND METHODS FOR SEEKING WITHIN MULTIMEDIA CONTENT DURING STREAMING PLAYBACK

CROSS-REFERENCE TO RELATED APPLICATIONS

The current application is a continuation of U.S. patent application Ser. No. 15/682,379, entitled "Video Distribution System Including Progressive Playback", filed Aug. 21, 2017, which is a continuation of U.S. patent application Ser. No. 14/632,670, entitled "Video Distribution System Including Progressive Playback", filed Feb. 26, 2015, which is a continuation of U.S. patent application Ser. No. 12/982,413, entitled "Video Distribution System Including Progressive Playback", filed Dec. 30, 2010 and issued as U.S. Pat. No. 8,977,768 on Mar. 10, 2015, which is a continuation of U.S. patent application Ser. No. 11/970,493, entitled "Video Distribution System Including Progressive Playback", filed Jan. 7, 2008 and issued as U.S. Pat. No. 7,886,069 on Feb. 8, 2011, which claims priority to U.S. Provisional Application Ser. No. 60/883,659, entitled "Video Distribution System Including Progressive Playback", filed Jan. 5, 2007, the disclosures of which are incorporated herein by reference.

BACKGROUND

The present invention relates generally to playing multimedia files over a network and more specifically to the progressive playback of multimedia files as they are downloaded over a network.

Progressive playback is the idea of playing back remote content as it is being downloaded. With this feature a user can select a remote movie and commence watching it before it is fully downloaded. Even with a fast Internet connection, waiting for a movie to fully download can range from minutes to hours depending on the size of the media file. With progressive playback a user only has to wait a couple of seconds before playback can begin.

Current implementations of receiver or player driven progressive playback, while suitable for the short video clips that are dominant in many current applications, are typically limited in the scope and flexibility of the progressive playback they provide. Players typically download files linearly from the beginning to the end. Playback then begins when the player has buffered enough data to provide a likelihood that the media will play without interruption. The buffering requirement can either be a fixed amount suitable for a large percentage of content, or a dynamic amount, where the player infers how much data is required to play the entire content without suffering buffer under-run. Although suitable for playback of short video clips, these methods typically do not support random seeking, trick-play and playback of remotely stored longer content such as feature length movies.

Some systems are implemented with a server driven approach. Examples of server driven approaches include the systems described in U.S. patent application Ser. Nos. 11/323,044, 11/323,062, 11/327,543, and 11/322,604, the disclosure of which is incorporated herein by reference in its entirety. In these systems, the server parses the data file and determines which data to send. Network efficiency and flexibility in playback becomes a much easier task. Standard HTTP web servers however do not typically provide this functionality, and custom web servers providing this functionality often scale poorly when called upon to deliver content simultaneously to a large number of players.

Browser based players often implement receiver driven playback by parsing the video file as it is downloaded linearly. When a long clip is started, it is impossible to seek or fast-forward to a point in the file that has not already been downloaded. Samba (open source software available at http://us2.samba.org/samba/) can be used to give any application access to a remote file as if it were a local file. It tries to minimize the access latency by pre-caching data from the current file position, which can be randomly set. This may be insufficient when trying to perform "trick play" functions (e.g. performing functions such as rewinding, fast forwarding and skipping between scenes that require non-sequential access of media content). The video frames to be delivered to the player in these scenarios can be spaced far apart or require more complex ordering, greatly diminishing the utility of traditional pre-caching methods which are based on assumptions regarding the subsequent video frames to be viewed.

SUMMARY OF THE INVENTION

Systems and methods are described for performing progressive playback and "trick play" functions on partially downloaded media files. Many embodiments of the invention include a receiver or player driven system supporting features such as the maintenance at all times of a full capacity download stream of only certain required data, including data in certain byte ranges, the discarding of previous requests, and the issuing of new requests for data at the highest priority. Additionally, several embodiments of the invention include features such as random file access at any point in a file, and asynchronous requests, which provide users flexibility in the playback of a file. In a number of embodiments, the systems and processes support scalability for implementation on Internet servers that store files that can contain multiple titles, titles that include multiple audio tracks, and/or titles that include one or more subtitle tracks.

In several embodiments, the ability to provide full featured progressive playback is due in part to the tight coupling of the playback engine for the media sequence (i.e., the system that decodes and plays back the encoded media) with a transport protocol that provides random access to the remote file. Interfacing of the playback engine with the transport protocol via a file parser can reduce latency and enable the client and media server to operate in parallel improving download efficiency and interactivity. In a number of embodiments, the system and processes are configured for use with files that are formatted to include an index to the data within the file and a transport protocol that allows for downloading specific byte ranges within a file.

One embodiment of the method of the invention includes, obtaining information concerning the content of the media file from the remote server, identifying a starting location within the media sequence, identifying byte ranges of the media file corresponding to media required to play the media sequence from the starting location, requesting the byte ranges required to play the media sequence from the starting location, buffering received bytes of information pending commencement of playback, playing back the buffered bytes of information, receiving a user instruction, identifying byte ranges of the media file corresponding to media required to play the media sequence in accordance with the user instruction, flushing previous byte range requests, and requesting the byte ranges required to play the media in accordance with the user instruction.

US 10,412,141 B2

3   4

A further embodiment of the method of the invention includes, maintaining a mask of the portions of the media file that have been downloaded, identifying that at least a portion of a byte range required to play the media in accordance with the user instruction has already been downloaded using the mask, and requesting only the portions of byte ranges that have not already been downloaded from the media server.

Another embodiment of the method of the invention includes storing downloaded bytes in a data file, and outputting the downloaded media file when all bytes of the media file have been downloaded.

In a still further embodiment of the method of the invention, the data file is a sparse data file.

In still another embodiment of the method of the invention, the media file contains a plurality of media sequences and menu information, and identifying a starting location within the media sequence further includes displaying menu information, receiving a user instruction indicative of the selection of the media sequence, and receiving a user instruction indicative of a starting location within the media sequence.

In a yet further embodiment of the method of the invention, the media sequence includes a plurality of interchangeable audio tracks, identifying a starting location within the media sequence further comprises selecting an audio track, and identifying byte ranges of the media file corresponding to media required to play the media sequence from the starting location further comprises selecting byte ranges that do not include the audio tracks that were not selected.

In yet another embodiment of the method of invention, the media sequence includes a plurality of interchangeable subtitle tracks, identifying a starting location within the media sequence further comprises selecting a subtitle track, and identifying byte ranges of the media file corresponding to media required to play the media sequence from the starting location further includes selecting byte ranges that do not include the subtitle tracks that were not selected.

In a further embodiment again of the method of the invention, the sequence includes key frames, and identifying byte ranges of the media file corresponding to media required to play the media in accordance with the user instruction further includes identifying a sequence of key frames in response to a predetermined user instruction, and identifying byte ranges of the media file corresponding to the identified key frames.

One embodiment of the invention includes a media server, a client, and a network. In addition, the client and the media server are configured to communicate via the network, the client is configured to send requests for at least one portion of the media file to the media server, the server is configured to provide requested portions of the media file to the client, and the client is configured to receive user instructions concerning the playback of the media file and to request portions of the media file that have not been downloaded and that are required to comply with the playback instructions from the media server.

In a further embodiment of the invention, proximate portions of the media file grouped and the groups are requested on an earliest deadline first basis.

In another embodiment of the invention, the client is configured to maintain a queue of requested portions of the media file.

In a still further embodiment of the invention, the client and the server are configured to communicate via at least one connection, and the client is configured to flush the queue of requested portions of the media file and break at least one of the connections in response to the receipt of a predetermined user instruction.

In still another embodiment of the invention, the client is configured to store a file map and a data file, the file map contains a mask indicating the portions of the media file that have been downloaded, and the data file contains the downloaded portions of the media file.

In a yet further embodiment of the invention, the data file is a sparse file.

In yet another embodiment of the invention, the media file includes a media sequence and an index, and the client includes a playback engine configured to obtain the index and determine the portions of the media sequence required to comply with user playback instructions, a file parser configured to use the index to map the portions of the media sequence to portions of the media file and a download manager configured to communicate with the media server to download portions of the media file.

A further embodiment again of the invention includes a user interface configured to receive user instructions, a storage device configured to store at least one media file, a network connection, a download manager configured to asynchronously request at least one byte range of a file from a remotely stored media file via the network connection, a playback engine configured to determine portions of a remotely stored media file that must be downloaded in response to user instructions received via the user interface, and a file parser configured to translate requests for portions of a remotely stored media file to byte ranges and to provide the byte ranges to the download manager.

In another embodiment again of the invention, the download manager is configured to create a status file containing a map of blocks of a media file that have been downloaded, and the download manager is configured to create a data file in which to store blocks of a downloaded media file.

In a further additional embodiment of the invention, the download manager is configured to maintain a queue of requested byte ranges.

In another additional embodiment of the invention, the download manager is configured to flush the queue.

In a still yet further embodiment of the invention, the playback engine is configured to generate a menu using menu information obtained from a remote media file.

In still yet another embodiment of the invention, the playback engine is configured to receive a selection of one of a plurality of media sequences in a remote media file via the menu.

In a still further embodiment again of the invention, the playback engine is configured to receive a selection of one of a plurality of audio tracks for a media sequence in a remote media file via the menu.

In still another embodiment again of the invention, the playback engine is configured to receive a selection of a subtitle track for a media sequence in a remote media file via the menu.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a semi-schematic network diagram of progressive playback system in accordance with an embodiment of the invention.

FIG. 2 is a flow chart showing a process for progressively playing back a remotely stored media file in accordance with an embodiment of the invention.

FIG. 3 is a conceptual illustration of a client application configured to request byte ranges from a remote server and

US 10,412,141 B2

5   6

to support "trick play" functions in accordance with an embodiment of the invention.

FIG. 4 is a conceptual illustration of a download manager in accordance with an embodiment of the invention.

FIG. 5 is a flow chart showing a process for requesting byte ranges from a media server in accordance with an embodiment of the invention.

FIG. 6 is a flow chart showing a process for flushing a connection with a media server in accordance with an embodiment of the invention.

FIG. 7 is a flow chart showing a process for building a data file during the non-sequential downloading of byte ranges of the data file in accordance with an embodiment of the invention.

FIG. 8 is a flow chart showing a process that can be used by a file parser to identify menu information and media sequences within a remote media file and to extract information from the file in accordance with an embodiment of the invention.

FIG. 9 is a flow chart showing a process used by a playback engine to obtain data chunks from a remote media file formatted using a container format that utilizes chunks in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE
INVENTION

Turning now to the drawings, a system for progressively downloading and playing media is shown. In many embodiments, the media is stored in a file on a remote server and a device configured with a client application retrieves portions of the media file and plays the media. The client application typically does not possess the entire media file when it commences playing and can request non-sequential portions of the media file. In this way, the client application can support "trick play" functions. "Trick play" functions impact the playing of a media file such as non-sequential functions including pausing, rewinding, fast forwarding and skipping between scenes. Instead of sequentially downloading a media file and waiting until the required information has been downloaded to perform a "trick play" function, client applications in accordance with embodiments of the invention can determine portions of a media file that are required to support a specific "trick play" function and request those portions of the file from the remote server. When a "trick play" function involves skipping to portions of the media that have not been downloaded, such as fast forwarding and skipping between chapters, latency can be significantly reduced compared to sequential download.

The configuration of a progressive playback system in accordance with an embodiment of the invention can depend upon the container formats supported by the progressive playback system. Examples of container formats include the AVI 1.0 file format specified by Microsoft Corporation of Redmond, Wash., the OpenDML AVI or AVI 2.0 format, container formats similar to the formats specified in U.S. patent application Ser. Nos. 11/016,184 and 11/198,142, the disclosure of which is incorporated herein by reference in its entirety, MPEG-4 Part 15 (MP4) and the open source format known as Matroska (see www.matroska.org). Depending upon the container file format used, a media file can include multiple titles (i.e. media sequences) and each title can include multiple audio tracks and/or one or more subtitle tracks. The container format of a media file influences the manner in which media information within a media file is located. Therefore, the configuration of a progressive playback system is typically determined based upon the container formats supported in a specific application. Although numerous embodiments are discussed below, other variations appropriate to different container formats can be constructed in accordance with embodiments of the invention.

A progressive playback system in accordance with an embodiment of the invention is shown in FIG. 1. The progressive playback system 10 includes a media server 12 connected to a network 14. Media files are stored on the media server 14 and can be accessed by devices configured with a client application. In the illustrated embodiment, devices that access media files on the media server include a personal computer 16, a consumer electronics device such as a set top box 18 connected to a playback device such as a television 20, and a portable device such as a personal digital assistant 22 or a mobile phone handset. The devices and the media server 12 can communicate over a network 14 that is connected to the Internet 24 via a gateway 26. In other embodiments, the media server 14 and the devices communicate over the Internet.

The devices are configured with client applications that can request portions of media files from the media server 12 for playing. The client application can be implemented in software, in firmware, in hardware or in a combination of the above. In many embodiments, the device plays media from downloaded media files. In several embodiments, the device provides one or more outputs that enable another device to play the media. When the media file includes an index, a device configured with a client application in accordance with an embodiment of the invention can use the index to determine the location of various portions of the media. Therefore, the index can be used to provide a user with "trick play" functions. When a user provides a "trick play" instruction, the device uses the index to determine the portion or portions of the media file that are required in order to execute the "trick play" function and requests those portions from the server. In a number of embodiments, the client application requests portions of the media file using a transport protocol that allows for downloading of specific byte ranges within the media file. One such protocol is the HTTP 1.1 protocol published by The Internet Society or BitTorrent available from www.bittorrent.org. In other embodiments, other protocols and/or mechanisms can be used to obtain specific portions of the media file from the media server.

A flow chart showing a process for requesting media from a media server in accordance with an embodiment of the invention is shown in FIG. 2. The process 40 includes obtaining (42) the index of the media file from the media server. A location from which to start playing the media file is then determined (44). In a number of embodiments, all files commence playing at the start of a media sequence. In several embodiments, the media file can include one or more menus that enable a user to select different locations from which to commence viewing one or more media sequences. Once a location has been determined, the media information required to commence playing the media from the determined location is requested (46) and played back (48) upon receipt. The process involves listening (50) for user instructions. In the event that a user does not provide an instruction, the system continues playing the media in accordance with previous instructions received from the user. When a user provides an instruction, the process determines (52) whether the instruction is to cease playing. Otherwise, the process involves determining (54) the media required to comply with the instruction and requesting (46) the required media.

US 10,412,141 B2

7   8

The process continues until the user provides an instruction to stop playing the media or the end of the media sequence is reached.

Media servers in accordance with embodiments of the invention can support progressive playback and trick play functions by simply storing media files and receiving requests for specific byte ranges within the media file. The client application can determine the appropriate byte ranges and the media server simply responds to the byte range requests. A client application that is configured to determine appropriate byte ranges in response to user instructions can be implemented in a variety of ways.

A client application implemented using three abstraction layers in accordance with an embodiment of the invention is illustrated in FIG. **3**. The client application **60** includes a download manager **62** that is responsible for coordinating the downloading of specific byte ranges of a file from a remote server. The playback engine **64** is a high level process that coordinates the playback of a media file in response to user interactions. When a media file is being played, the playback engine uses an index of the media file to determine the portions of the media file required to continue playing the media and/or to respond to user instructions. A file parser **66** interfaces between the playback engine **64** and the download manager **62**. The file parser maps high level data requests from the playback engine to specific byte ranges that can then be requested using the download manager. The implementation of download managers, file parsers and playback engines in accordance with embodiments of the invention is discussed below. In many embodiments, client applications are configured using alternative architectures that are configured to use an index to a media file to convert user instructions into byte requests that are provided to a remote media server.

A download manager in accordance with an embodiment of the invention is illustrated in FIG. **4**. As discussed above, the download manager is responsible for communicating with one or more media servers and obtaining specific byte ranges of media from media files stored on the media servers. The download manager **70** shown in FIG. **4** is configured to instantiate a remote file object **72** and a partial file object **74** to assist with the downloading of media files. The remote file object **72** handles the communications associated with requesting byte ranges of a file from a media server and maintains a queue of the byte ranges that have been requested. The partial file object **74** handles storage of the data downloaded from the media server. The partial file object **74** establishes a temporary data path **75** for a file being downloaded by the download manager.

The temporary data path **75** includes a data file **78** and a status file **76**. The data file **76** contains data received from the media server. The status file contains a mask of the data file, where each bit within the mask corresponds to a block of fixed size within the data file. As blocks are downloaded, bits within the mask are set. A status file can also include a region for external data, which can include information, such as the last modified server timestamp, that can be used by the download manager to determine if any partially downloaded data has expired. When the entire media file has been downloaded, the download manager creates an output file path **80** and fully downloaded version of the remote file **82** is output to the download path. At which point, the client application can use the local file to play the media and support "trick play" functions in a conventional manner.

Depending upon the size of the file being downloaded, the data file can be several gigabytes in length. A common file allocation approach is to allocate zeros for every byte within the file, which can take several minutes to complete for large files. Latency during data file allocation can be reduced by allocating the file as a sparse file that only uses the number of bytes actually written to the file. When a sparse file is used, the file allocation process requires very little time. In other embodiments, other file allocation approaches can be used that weight latency against the needs of the download manager.

The block size of the data file (as represented in the status file) determines the granularity by which data can be downloaded. A small block size is typically more efficient in terms of downloading only needed bytes. However small block sizes can lead to a large mask size. In many embodiments, a block size of 128 is used to compromise between efficiency and mask size. In other embodiments, other block sizes determined based upon the requirements of the application are utilized.

A process for requesting data using the download manager in accordance with an embodiment of the invention is shown in FIG. **5**. The process **90** commences when a request is received (**91**) to download a byte range from a media file stored on a remote server. When a download manager similar to the download manager shown in FIG. **4** is used, the download manager instantiates a remote file object and a partial file object and creates the necessary supporting files. A connection is established (**92**) with the remote server, the requested byte range is placed (**94**) in a request queue and is then requested (**96**). As more byte ranges are received, the process determines whether any of the bytes within a requested byte range have been previously downloaded and only places portions of the byte range that have not been previously downloaded in the request queue.

When a download manager similar to that shown in FIG. **4** is used to implement the process **90** in FIG. **5**, the mask in the status file **76** is used to determine the requested bytes that have already been stored in the data file **78** and the remaining bytes that should be requested. Each byte range request has associated overhead, therefore, a number of embodiments of the invention include multiple byte ranges in a byte range request and/or search the request queue for byte ranges proximate the byte range at the front of the queue and request a large byte range that encompasses all of the proximate byte range. In several embodiments, the process opens multiple connections to increase download data rate and/or accommodate servers that limit the number of byte requests that can be made via a connection. Again, opening connections has associated overhead. Therefore, the number of connections can be limited based upon a limit appropriate to a particular application (e.g. 5).

When a determination (**100**) is made that there are no more byte ranges in the request queue, the process determines (**102**) whether the entire file has been downloaded. In the event that the entire file has not been downloaded, the process requests missing bytes from the partially downloaded file object. Once the entire file is downloaded, the downloaded file is exported to its output directory and the connection with the remote server is closed (**104**) and the process is complete. In many embodiments, the data file is exported only after playback is complete.

Although a specific process for downloading byte ranges is shown in FIG. **5**, variations on this process and/or alternative processes that enable the downloading of specific byte ranges and assembly of a data file can be used in accordance with embodiments of the invention. In addition, processes can involve any of a variety of optimizations to minimize the impact of communication overhead on media playback.

Appx60

US 10,412,141 B2

9 | 10

When a user provides a "trick play" instruction, previously requested byte ranges may no longer be required in order to continue playing media in the manner instructed by the user. Download managers in accordance with a number of embodiments of the invention possess the ability to flush the queue of pending byte range requests and establish a new queue of byte range requests. An advantage of flushing a request queue is that there is no latency associated with waiting until previously requested byte ranges have been requested prior to downloading the now higher priority byte ranges. In a number of embodiments, closing the connection with the remote server and opening a new connection further reduces latency. Closing the connection can remove latency associated with waiting for the media server to respond to pending download requests prior to the media server responding to new download requests.

A process for flushing a request queue in accordance with an embodiment of the invention is shown in FIG. **6**. The process **110** includes receiving (**112**) a flush request, flushing (**114**) the request queue and closing (**116**) the connection with the media server. In many embodiments, other processes can be used to reduce latency when "trick play" requests are received that eliminate the immediate need for portions of a media file previously requested and create an immediate need for portions of a remote media file that have not been previously requested.

When data is received by the download manager, the status file and the data file are both updated to reflect the received bytes. A process for handling receiving bytes from a remote media server in accordance with an embodiment of the invention is shown in FIG. **7**. The process **130** includes receiving (**132**) bytes, updating (**134**) the mask in the status file and updating (**136**) the data file. A determination (**138**) is then made as to whether the entire file has been downloaded. In the even that the entire file has not been downloaded, the process waits to receive additional bytes. When the entire file has been downloaded, the downloaded media file is exported (**140**) to its output directory. In other embodiments, other processes are used to organize received byte ranges.

A file parser in accordance with embodiments of the invention is used to convert high level requests from a playback engine into byte range requests for the download manager and to pass byte ranges downloaded by the download manager to the playback engine. When a device commences progressively playing a media file stored on a remote media server, the file parser accesses the file and downloads information concerning the content of the media file. Media files such as the media files described in U.S. patent application Ser. Nos. 11/016,184 and 11/198,142, incorporated by reference above include menu information and/or information from multiple media sequences (i.e. distinct media presentations). The file parser obtains menu information and information concerning the media sequences. When a media sequence is selected by the user, the file parser obtains an index to the selected media sequence and the index is used to identify the byte ranges within the remote media file to request as the media sequence is played.

A process in accordance with an embodiment of the invention for determining the media sequences contained within a remote media file and extracting selected media in accordance with an embodiment of the invention is shown in FIG. **8**. The process **150** includes obtaining (**152**) any menu information contained within the file and information concerning the number of distinct media sequences within the media file. In embodiments where a file parser is used in conjunction with a download manager, the file parser uses knowledge concerning media formats to select bytes of information to request from the media file using the download manager. The menu information and/or the information concerning the number of media sequences can be used to obtain (**154**) information concerning each of the media sequences. Information that can be useful includes information concerning the title of the media sequence, the format of the media sequence, the number of alternate audio tracks in the media sequence, the presence of one or more subtitle tracks in the media sequence and/or any additional information that could be useful to a user in the selection of a media sequence or to a decoder in the decoding of the media sequence. When the media is formatted in an AVI format or in a format similar to any of the file formats described in U.S. patent applications Ser. Nos. 11/016,184 and 11/198, 142, information concerning each of the media sequences can be downloaded by downloading the RIFF header for each media sequence. Once information concerning the media sequences has been obtained, a selection (**154**) can be made concerning the media sequence that is to be played. When the media file contains a single media sequence, the decision can be automatic. When the media file contains multiple sequences, the decision can be made based upon a user instruction that is obtained via a menu interface generated using menu information obtained from the remote media file by the file parser. The file parser uses the information obtained concerning the media sequence to direct the download manager to download a byte range corresponding to an index (**156**) for the media sequence. The file parser can use the index to extract (**158**) data from the remote file. The player engine determines the data that is extracted by the file parser. The manner in which the data is extracted depends upon the format of the media file. When the media file is formatted in a media format that utilizes chunks, the file parser uses the index to convert a chunk reference into specific byte ranges that can be retrieved using the download manager. When other formats are used, the file parser uses byte mappings appropriate to the file descriptive information available to the file parser. In addition to requesting byte ranges, file parsers in accordance with embodiments of the invention can communicate with a download manager to check on the status of a particular request and can provide downloaded bytes to the playback engine.

The primary goal of the playback engine, when progressively playing a remote file, is to always maintain a queue of media information required to play the file in the manner requested by the user. When a media file includes an index, the playback engine can refer to the index to determine the media information required to play the media file in the manner requested by the user. A process in accordance with an embodiment of the invention that is used to obtain media from a file that is formatted to represent the media as chunks of information is shown in FIG. **9**. The process **190** includes obtaining (**192**) an index from the remote media file. In embodiments where the playback engine requests information via a file parser, the playback engine can provide an instruction to the file parser to obtain the index and the file parser can extract the necessary information using the download manager. The playback engine then selects (**194**) chunks based upon instructions, including "trick play" instructions, received from the user and provides instructions to the file parser to download (**196**) the selected chunks. In a number of embodiments, the playback engine selects chunks based upon an earliest deadline first selection strategy. Chunks from unused audio tracks and unused

US 10,412,141 B2

11

subtitle tracks multiplexed within the media sequence can be ignored. In many embodiments, media chunks are requested prior to the downloading of the entire index. Media is typically played form the start of a media sequence, therefore, chunks from the start of the media sequence can be downloaded as the index is downloaded. When the playback engine receives the chunks from the file parser, the chunks are queued and provided to an appropriate decoder to enable the playing (**198**) of the media. Playback of the movie can begin once enough of the movie has been downloaded. The buffered length can be determined by the length of the playback list shared with the chunk download component.

The chunk selection process described above with respect to FIG. **9** maintains a queue of requested chunks. The queue can be maintained as a list of index entries for the requested chunks. The chunk download process polls the download status of the requested chunks. Once downloaded, a chunk is removed from the queue of requested chunks and the downloaded chunk is delivered to the chunk playback process.

When a "trick play" instruction is received, the playback engine selects media information appropriate to the "trick play" instruction. For example, a playback engine that receives a fast-forward or rewind instruction can request only key frames (i.e. complete frames) that are spaced throughout the media sequence at a timing determined by the rate of the trick play function. In many embodiments, the spacing in time is 0.1× the trick frame rate to provide a playback rate during trick play of 10 key frames per second. In other embodiments, various other algorithms are used to determine the media to request. Once the chunks containing the key frames have been identified, the playback engine requests the chunks using the file parser and download manager.

While the above description contains many specific embodiments of the invention, these should not be construed as limitations on the scope of the invention, but rather as an example of one embodiment thereof. Much of the discussion provided above assumes a media file having an index identifying the location of different pieces of media information within the media file. In many embodiments, hierarchical indexes and/or other index formats are included in media files and the playback engine and file parser are configured to accommodate the particular index structure. In several embodiments, the client application is configured to accommodate multiple file formats including file formats that do not possess indexes, but utilize other information to describe the content of the media file. Accordingly, the scope of the invention should be determined not by the embodiments illustrated, but by the appended claims and their equivalents.

What is claimed is:

1. A playback device, comprising:
a processor; and
a non-volatile storage containing an application for causing the processor to perform the steps of:
establishing at least one connection for communicating with a remote server system;
obtaining information from a remote server system describing at least one video track, multiple audio tracks, and multiple subtitle tracks;
selecting a video track from the at least one video track;
requesting a header describing the selected video track;
selecting an audio track from the multiple audio tracks;
obtaining index information indicating the locations of audio and video data within the selected audio and video tracks;

12

determining byte ranges to request from the selected audio and video tracks using the index information;
requesting byte ranges from the selected video track and the selected audio track from the remote server system;
buffering received bytes of information comprising audio and video data;
checking that sufficient data is buffered to commence playback and playing back the buffered audio and video data;
responding to a received seek instruction by:
pausing playback;
determining byte ranges to request from the selected audio and video tracks based upon a new playback location using the index information;
requesting byte ranges required to play the selected audio and video tracks from the new playback location from the remote server;
buffering received bytes of information comprising audio and video data pending resumption of playback; and
checking that sufficient data is buffered to commence playback and playing back the buffered audio and video data.

2. The playback device of claim **1**, wherein the application is further capable of causing the processor to asynchronously request byte ranges from the selected video track and the selected audio track from the remote server.

3. The playback device of claim **1**, wherein the step of requesting a header describing the selected video track comprises the step of requesting a DRM header.

4. The playback device of claim **3**, wherein the application is further capable of causing the processor to perform the step of decrypting the DRM header.

5. The playback device of claim **3**, wherein:
the DRM header identifies at least one key; and
the application is further capable of causing the processor to perform the steps of decrypting encrypted frames of video using the at least one key prior to decoding.

6. The playback device of claim **5**, wherein:
encrypted frames of video are only partially encrypted;
the received bytes of information contain references to portions of video frames that are encrypted; and
the step of decrypting encrypted frames of video using the at least one key prior to decoding further comprises decrypting encrypted portions of frames of video using the references to the portions of the video frames that are encrypted.

7. The playback device of claim **1**, wherein playing back the buffered video data from the requested byte ranges provides fast forward trick play.

8. The playback device of claim **1**, wherein playing back the buffered video data from the requested byte ranges provides fast rewind trick play.

9. The playback device of claim **1**, wherein the application is further capable of causing the processor to perform the step of discarding audio and video data contained within the buffer in response to a received seek instruction.

10. The playback device of claim **1**, wherein the application is further capable of causing the processor to perform the steps of:
selecting a subtitle track from the multiple subtitle tracks;
requesting data from the selected subtitle track from the remote server system, where the data contains subtitle text; and
superimposing the subtitle text over video during playback.

US 10,412,141 B2

13

11. The playback device of claim **1**, wherein the application is further capable of causing the processor to perform the step of flushing previous byte range requests in response to the received seek instruction.

12. A playback device, comprising:

a processor; and

a non-volatile storage containing an application for causing the processor to perform the steps of:

establishing at least one connection for communicating with a remote server system;

obtaining information from a remote server system describing at least one video track, and at least one audio track;

selecting a video track from the at least one video track;

requesting a header describing the selected video track, where the requested header comprises a DRM header;

decrypting the DRM header;

selecting an audio track from the at least one audio track;

obtaining index information indicating the locations of audio and video data within the selected audio and video tracks;

determining byte ranges to request from the selected audio and video tracks using the index information;

creating a buffer;

requesting byte ranges from the video track and the audio track from the remote server system;

buffering received bytes of information comprising audio and video data;

checking that sufficient data is buffered to commence playback;

decrypting encrypted frames of video using information from the decrypted DRM header;

playing back the buffered audio and the decrypted video data;

responding to a received seek instruction by:

pausing playback;

discarding buffered audio and video data;

determining byte ranges to request from the selected audio and video tracks based upon a new playback location using the index information;

requesting byte ranges required to play the selected audio and video tracks from the new playback location from the remote server;

buffering received bytes of information comprising audio and video data pending resumption of playback;

checking that sufficient data is buffered to commence playback;

decrypting encrypted frames of video using information from the decrypted DRM header; and

playing back the buffered audio and decrypted video data.

13. The playback device of claim **12**, wherein:

the DRM header identifies at least one key; and

the step of decrypting encrypted frames of video using information from the decrypted DRM header comprises decrypting encrypted frames of video using the at least one key prior to decoding.

14. The playback device of claim **13**, wherein:

encrypted frames of video are only partially encrypted;

the received bytes of information contain references to portions of video frames that are encrypted; and

the step of decrypting encrypted frames of video using the at least one key prior to decoding further comprises

14

decrypting encrypted portions of frames of video using the references to the portions of the video frames that are encrypted.

15. The playback device of claim **12**, wherein the application is further capable of causing the processor to asynchronously request byte ranges from the selected video track and the selected audio track from the remote server.

16. The playback device of claim **12**, wherein playing back the buffered video data from the requested byte ranges provides fast forward trick play.

17. The playback device of claim **12**, wherein playing back the buffered video data from the requested byte ranges provides fast rewind trick play.

18. The playback device of claim **12**, wherein the application is further capable of causing the processor to perform the steps of:

obtaining information from a remote server system describing at least one subtitle track;

selecting a subtitle track from the at least one subtitle track;

requesting data from the selected subtitle track from the remote server system, where the data contains subtitle text; and

superimposing the subtitle text over video during playback.

19. The playback device of claim **12**, wherein the application is further capable of causing the processor to perform the step of flushing previous byte range requests in response to the received seek instruction.

20. A method of playing back content on a playback device, comprising:

establishing at least one connection for communicating with a remote server system using a playback device;

obtaining information from a remote server system using the playback device, where the obtained information describes at least one video track, multiple audio tracks, and multiple subtitle tracks;

selecting a video track from the at least one video track;

requesting a header describing the at least one video track using the playback device;

selecting an audio track from the multiple audio tracks using the playback device;

obtaining index information indicating the locations of audio and video data within the selected audio and video tracks;

determining byte ranges to request from the selected audio and video tracks using the index information;

requesting byte ranges from the selected video track and the selected audio track from the remote server system using the playback device;

buffering received bytes of information comprising audio and video data on the playback device;

checking that sufficient data is buffered to commence playback and playing back the buffered audio and video data using the playback device;

responding to receipt of a seek instruction at the playback device by:

pausing playback on the playback device;

determining byte ranges to request from the selected audio and video tracks based upon a new playback location using the index information;

requesting byte ranges required to play the selected audio and video tracks from the new playback location from the remote server using the playback device;

US 10,412,141 B2

15

buffering received bytes of information comprising audio and video data pending resumption of playback using the playback device; and

checking that sufficient data is buffered to commence playback and playing back the buffered audio and video data using the playback device.

21. The method of claim **20**, further comprising asynchronously requesting byte ranges from the selected video track and the selected audio track from the remote server using the playback device.

22. The method of claim **20**, wherein requesting a header describing the selected video track further comprises requesting a DRM header using the playback device.

23. The method of claim **22**, further comprising decrypting the DRM header.

24. The method of claim **23**, wherein:

the DRM header identifies at least one key; and

the method further comprises decrypting encrypted frames of video using the at least one key prior to decoding using the playback device.

25. The method of claim **24**, wherein:

encrypted frames of video are only partially encrypted;

the received bytes of information contain references to portions of video frames that are encrypted; and

decrypting encrypted frames of video using the at least one key prior to decoding further comprises decrypting

16

encrypted portions of frames of video using the references to the portions of the video frames that are encrypted using the playback device.

26. The method of claim **20**, wherein playing back the buffered video data from the requested byte ranges provides fast forward trick play.

27. The method of claim **20**, wherein playing back the buffered video data from the requested byte ranges provides fast rewind trick play.

28. The method of claim **20**, further comprising discarding audio and video data contained within the buffer in response to a received seek instruction.

29. The method of claim **20**, further comprising:

selecting a subtitle track from the multiple subtitle tracks using the playback device;

requesting data from the selected subtitle track from the remote server system using the playback device, where the data contains subtitle text; and

superimposing the subtitle text over video during playback using the playback device.

30. The method of claim **20**, further comprising flushing previous byte range requests in response to the received seek instruction.

* * * * *

US010484749B2

(12) **United States Patent**
Chan et al.

(10) **Patent No.:   US 10,484,749 B2**
(45) **Date of Patent: *Nov. 19, 2019**

(54) **SYSTEMS AND METHODS FOR SECURE PLAYBACK OF ENCRYPTED ELEMENTARY BITSTREAMS**

(71) Applicant: **DIVX, LLC**, San Diego, CA (US)

(72) Inventors: **Francis Yee-Dug Chan**, San Diego, CA (US); **Kourosh Soroushian**, San Diego, CA (US); **Andrew Jeffrey Wood**, San Diego, CA (US)

(73) Assignee: **DIVX, LLC**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/136,170**

(22) Filed: **Sep. 19, 2018**

(65) **Prior Publication Data**

US 2019/0020928 A1   Jan. 17, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/615,626, filed on Jun. 6, 2017, now Pat. No. 10,212,486, which is a
(Continued)

(51) **Int. Cl.**
H04L 29/06   (2006.01)
H04N 21/6334   (2011.01)
(Continued)

(52) **U.S. Cl.**
CPC ... *H04N 21/63345* (2013.01); *H04L 63/0428* (2013.01); *H04L 65/607* (2013.01);
(Continued)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56)   **References Cited**

U.S. PATENT DOCUMENTS

4,009,331 A   2/1977   Goldmark et al.
4,694,357 A   9/1987   Rahman et al.
(Continued)

FOREIGN PATENT DOCUMENTS

AU   2010203605 B2   5/2015
CN   1169229   12/1997
(Continued)

OTHER PUBLICATIONS

International Preliminary Report on Patentability for International Application No. PCT/US2010/56733, dated Jun. 5, 2012, 5 pgs.
(Continued)

Primary Examiner — Malcolm Cribbs
(74) *Attorney, Agent, or Firm* — KPPB LLP

(57)   **ABSTRACT**

Systems and methods for providing multimedia content from one process or component to another process or component over an unsecured connection are provided. One embodiment includes obtaining the cryptographic information, extracting the at least partially encrypted video data from the container file to create an elementary bitstream, enciphering the cryptographic information, inserting the cryptographic information in the elementary bitstream, providing the elementary bitstream to a video decoder, extracting the cryptographic information from the elementary bitstream at the video decoder, deciphering the cryptographic information, decrypting the elementary bitstream with the cryptographic information and decoding the elementary bitstream for rendering on a display device using the video decoder.

18 Claims, 8 Drawing Sheets
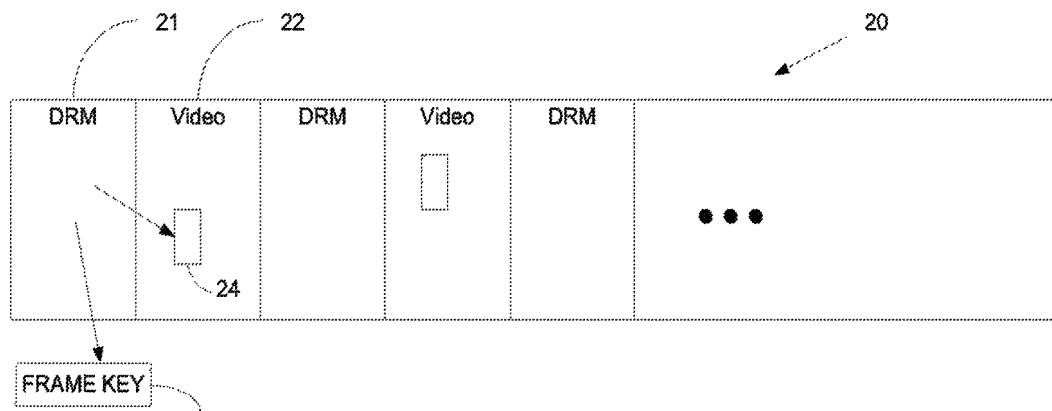
US 10,484,749 B2

Page 2

Related U.S. Application Data

continuation of application No. 14/839,783, filed on Aug. 28, 2015, now Pat. No. 9,706,259, which is a continuation of application No. 14/306,146, filed on Jun. 16, 2014, now Pat. No. 9,124,773, which is a continuation of application No. 12/946,631, filed on Nov. 15, 2010, now Pat. No. 8,781,122.

(60) Provisional application No. 61/266,982, filed on Dec. 4, 2009.

(51) **Int. Cl.**

H04N 21/235	(2011.01)
H04N 21/236	(2011.01)
H04N 21/434	(2011.01)
H04N 21/4405	(2011.01)
H04N 7/167	(2011.01)
H04N 21/43	(2011.01)

(52) **U.S. Cl.**
CPC *H04N 7/1675* (2013.01); *H04N 21/2351* (2013.01); *H04N 21/23614* (2013.01); *H04N 21/4302* (2013.01); *H04N 21/4348* (2013.01); *H04N 21/4405* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,802,170 A	1/1989	Trottier
4,964,069 A	10/1990	Ely
5,119,474 A	6/1992	Beitel et al.
5,274,758 A	12/1993	Beitel et al.
5,361,332 A	11/1994	Yoshida et al.
5,396,497 A	3/1995	Veltman
5,404,436 A	4/1995	Hamilton
5,420,801 A	5/1995	Dockter et al.
5,420,974 A	5/1995	Morris et al.
5,471,576 A	11/1995	Yee
5,479,303 A	12/1995	Suzuki et al.
5,487,167 A	1/1996	Dinallo et al.
5,502,766 A	3/1996	Boebert et al.
5,509,070 A	4/1996	Schull
5,533,021 A	7/1996	Branstad et al.
5,537,408 A	7/1996	Branstad et al.
5,539,908 A	7/1996	Chen et al.
5,541,662 A	7/1996	Adams et al.
5,583,652 A	12/1996	Ware
5,589,993 A	12/1996	Naimpally et al.
5,621,794 A	4/1997	Matsuda et al.
5,627,936 A	5/1997	Prasad
5,633,472 A	5/1997	DeWitt et al.
5,642,171 A	6/1997	Baumgartner et al.
5,655,117 A	8/1997	Goldberg et al.
5,664,044 A	9/1997	Ware
5,675,382 A	10/1997	Bauchspies
5,675,511 A	10/1997	Prasad et al.
5,684,542 A	11/1997	Tsukagoshi
5,715,403 A	2/1998	Stefik
5,717,816 A	2/1998	Boyce et al.
5,719,786 A	2/1998	Nelson et al.
5,745,643 A	4/1998	Mishina
5,751,280 A	5/1998	Abbott
5,754,648 A	5/1998	Ryan et al.
5,763,800 A	6/1998	Rossum et al.
5,765,164 A	6/1998	Prasad et al.
5,794,018 A	8/1998	Vrvilo et al.
5,805,700 A	9/1998	Nardone et al.
5,822,524 A	10/1998	Chen et al.
5,828,370 A	10/1998	Moeller et al.
5,841,432 A	11/1998	Carmel et al.
5,844,575 A	12/1998	Reid
5,848,217 A	12/1998	Tsukagoshi et al.
5,867,625 A	2/1999	McLaren
5,887,110 A	3/1999	Sakamoto et al.

5,892,900 A	4/1999	Ginter et al.
5,903,261 A	5/1999	Walsh et al.
5,907,597 A	5/1999	Mark
5,946,446 A	8/1999	Yanagihara
5,956,729 A	9/1999	Goetz et al.
5,959,690 A	9/1999	Toebes, VIII et al.
5,970,147 A	10/1999	Davis
5,999,812 A	12/1999	Himsworth
6,031,622 A	2/2000	Ristow et al.
6,038,257 A	3/2000	Brusewitz et al.
6,044,469 A	3/2000	Horstmann
6,046,778 A	4/2000	Nonomura et al.
6,047,100 A	4/2000	McLaren
6,058,240 A	5/2000	McLaren
6,064,794 A	5/2000	McLaren et al.
6,065,050 A	5/2000	DeMoney
6,018,611 A	6/2000	Nogami et al.
6,079,566 A	6/2000	Eleftheriadis et al.
6,097,877 A	8/2000	Katayama et al.
6,141,754 A	10/2000	Choy
6,155,840 A	12/2000	Sallette
6,169,242 B1	1/2001	Fay et al.
6,175,921 B1	1/2001	Rosen
6,195,388 B1	2/2001	Choi et al.
6,204,883 B1	3/2001	Tsukagoshi
6,222,981 B1	4/2001	Rijckaert
6,282,653 B1	8/2001	Berstis et al.
6,289,450 B1	9/2001	Pensak et al.
6,292,621 B1	9/2001	Tanaka et al.
6,308,005 B1	10/2001	Ando et al.
6,330,286 B1	12/2001	Lyons et al.
6,374,144 B1	4/2002	Viviani et al.
6,389,218 B2	5/2002	Gordon et al.
6,389,473 B1	5/2002	Carmel et al.
6,395,969 B1	5/2002	Fuhrer
6,397,230 B1	5/2002	Carmel et al.
6,418,270 B1	7/2002	Steenhof et al.
6,449,719 B1	9/2002	Baker
6,466,671 B1	10/2002	Maillard et al.
6,466,733 B1	10/2002	Kim
6,510,513 B1	1/2003	Danieli
6,510,554 B1	1/2003	Gordon et al.
6,621,979 B1	9/2003	Eerenberg et al.
6,625,320 B1	9/2003	Nilsson et al.
6,658,056 B1	12/2003	Duruöz et al.
6,665,835 B1	12/2003	Gutfreund et al.
6,671,408 B1	12/2003	Kaku
6,697,568 B1	2/2004	Kaku
6,725,281 B1	4/2004	Zintel et al.
6,771,703 B1	8/2004	Oguz et al.
6,807,306 B1	10/2004	Girgensohn et al.
6,810,031 B1	10/2004	Hegde et al.
6,810,389 B1	10/2004	Meyer
6,819,394 B1	11/2004	Nomura et al.
6,850,252 B1	2/2005	Hoffberg
6,856,997 B2	2/2005	Lee et al.
6,859,496 B1	2/2005	Boroczky et al.
6,917,652 B2	7/2005	Lyu
6,931,531 B1	8/2005	Takahashi
6,944,621 B1	9/2005	Collart
6,944,629 B1	9/2005	Shioi et al.
6,956,901 B2	10/2005	Boroczky et al.
6,965,724 B1	11/2005	Boccon-Gibod et al.
6,965,993 B2	11/2005	Baker
6,985,588 B1	1/2006	Glick et al.
6,988,144 B1	1/2006	Luken et al.
7,007,170 B2	2/2006	Morten
7,023,924 B1	4/2006	Keller et al.
7,043,473 B1	5/2006	Rassool et al.
7,103,906 B1	9/2006	Katz et al.
7,127,155 B2	10/2006	Ando et al.
7,150,045 B2	12/2006	Koelle et al.
7,151,832 B1	12/2006	Fetkovich et al.
7,151,833 B2	12/2006	Candelore et al.
7,165,175 B1	1/2007	Kollmyer et al.
7,185,363 B1	2/2007	Narin et al.
7,191,335 B1 *	3/2007	Maillard H04N 7/163
		348/E7.056
7,197,234 B1	3/2007	Chatterton

Appx66

US 10,484,749 B2

Page 3

(56)   **References Cited**

U.S. PATENT DOCUMENTS

7,206,940 B2	4/2007	Evans et al.	
7,209,892 B1	4/2007	Galuten et al.	
7,231,132 B1	6/2007	Davenport	
7,237,061 B1	6/2007	Boic	
7,242,772 B1	7/2007	Tehranchi	
7,243,346 B1	7/2007	Seth et al.	
7,295,673 B2	11/2007	Grab et al.	
7,328,345 B2	2/2008	Morten et al.	
7,330,875 B1	2/2008	Parasnis et al.	
7,340,528 B2	3/2008	Noblecourt et al.	
7,349,886 B2	3/2008	Morten et al.	
7,356,143 B2	4/2008	Morten	
7,356,245 B2	4/2008	Belknap et al.	
7,366,788 B2	4/2008	Jones et al.	
7,376,831 B2	5/2008	Kollmyer et al.	
7,406,174 B2	7/2008	Palmer	
7,421,411 B2	9/2008	Kontio et al.	
7,454,780 B2	11/2008	Katsube et al.	
7,457,359 B2	11/2008	Mabey et al.	
7,460,668 B2	12/2008	Grab et al.	
7,472,280 B2	12/2008	Giobbi	
7,478,325 B2	1/2009	Foehr	
7,484,103 B2	1/2009	Woo et al.	
7,493,018 B2	2/2009	Kim	
7,499,938 B2	3/2009	Collart	
7,515,710 B2	4/2009	Russell et al.	
7,526,450 B2	4/2009	Hughes et al.	
7,594,271 B2	9/2009	Zhuk et al.	
7,610,365 B1	10/2009	Kraft et al.	
7,640,435 B2	12/2009	Morten	
7,689,510 B2	3/2010	Lamkin et al.	
7,720,352 B2	5/2010	Belknap et al.	
7,747,853 B2	6/2010	Candelore et al.	
7,761,892 B2	7/2010	Ellis et al.	
7,779,097 B2	8/2010	Lamkin et al.	
7,788,271 B2	8/2010	Soma et al.	
7,817,608 B2	10/2010	Rassool et al.	
7,869,691 B2	1/2011	Kelly et al.	
7,882,034 B2	2/2011	Hug et al.	
7,949,703 B2	5/2011	Matsuzaki et al.	
7,962,942 B1	6/2011	Craner	
7,974,714 B2	7/2011	Hoffberg	
7,991,156 B1	8/2011	Miller	
8,023,562 B2	9/2011	Zheludkov et al.	
8,046,453 B2	10/2011	Olaiya	
8,054,880 B2	11/2011	Yu et al.	
8,065,708 B1	11/2011	Smyth et al.	
8,069,260 B2	11/2011	Speicher et al.	
8,082,442 B2	12/2011	Keljo et al.	
8,195,714 B2	6/2012	Mckibben et al.	
8,201,264 B2	6/2012	Grab et al.	
8,225,061 B2	7/2012	Greenebaum	
8,233,768 B2	7/2012	Soroushian et al.	
8,245,124 B1	8/2012	Gupta	
8,249,168 B2	8/2012	Graves	
8,261,356 B2	9/2012	Choi et al.	
8,265,168 B1	9/2012	Masterson et al.	
8,270,473 B2	9/2012	Chen et al.	
8,270,819 B2	9/2012	Vannier	
8,275,871 B2	9/2012	Ram et al.	
8,289,338 B2	10/2012	Priyadarshi et al.	
8,291,460 B1	10/2012	Peacock	
8,296,434 B1	10/2012	Miller et al.	
8,311,111 B2	11/2012	Xu et al.	
8,311,115 B2	11/2012	Gu et al.	
8,321,556 B1	11/2012	Chatterjee et al.	
8,341,715 B2	12/2012	Sherkin et al.	
8,386,621 B2	2/2013	Park	
8,396,114 B2	3/2013	Gu et al.	
8,401,900 B2	3/2013	Cansler et al.	
8,407,753 B2	3/2013	Kuo	
8,412,841 B2	4/2013	Swaminathan et al.	
8,423,889 B1	4/2013	Zagorie et al.	
8,452,110 B2	5/2013	Shoham et al.	
8,456,380 B2	6/2013	Pagan	
8,472,792 B2	6/2013	Butt et al.	
8,473,630 B1	6/2013	Galligan et al.	
8,510,303 B2	8/2013	Soroushian et al.	
8,510,404 B2	8/2013	Carmel et al.	
8,515,265 B2	8/2013	Kwon et al.	
8,516,529 B2	8/2013	Lajoie et al.	
8,527,645 B1	9/2013	Proffit et al.	
8,595,378 B1	11/2013	Cohn	
8,606,069 B2	12/2013	Okubo et al.	
8,640,166 B1	1/2014	Craner et al.	
8,649,669 B2	2/2014	Braness et al.	
8,656,183 B2	2/2014	Russell et al.	
8,677,428 B2	3/2014	Lewis et al.	
8,681,866 B1	3/2014	Jia	
8,689,267 B2	4/2014	Hunt	
8,726,264 B1	5/2014	Allen et al.	
RE45,052 E	7/2014	Li	
8,767,825 B1	7/2014	Wang et al.	
8,774,609 B2	7/2014	Drake et al.	
8,781,122 B2	7/2014	Chan et al.	
8,805,109 B2	8/2014	Shoham et al.	
8,806,188 B2	8/2014	Braness et al.	
8,832,434 B2	9/2014	Apostolopoulos et al.	
8,843,586 B2	9/2014	Pantos et al.	
8,856,218 B1	10/2014	Inskip	
8,908,984 B2	12/2014	Shoham et al.	
8,909,922 B2	12/2014	Kiefer et al.	
8,914,534 B2	12/2014	Braness et al.	
8,914,836 B2	12/2014	Shivadas et al.	
8,918,535 B2	12/2014	Ma et al.	
8,918,636 B2	12/2014	Kiefer	
8,918,908 B2	12/2014	Ziskind et al.	
8,948,249 B2	2/2015	Sun et al.	
8,997,161 B2	3/2015	Priyadarshi et al.	
8,997,254 B2	3/2015	Amidei et al.	
9,014,471 B2	4/2015	Shoham et al.	
9,025,659 B2	5/2015	Soroushian et al.	
9,042,670 B2	5/2015	Carmel et al.	
9,060,207 B2	6/2015	Scherkus et al.	
9,094,737 B2	7/2015	Shivadas et al.	
9,098,335 B2	8/2015	Muthiah et al.	
9,124,773 B2	9/2015	Chan et al.	
9,125,073 B2	9/2015	Oyman et al.	
9,184,920 B2	11/2015	Grab et al.	
9,191,457 B2	11/2015	Van Der Schaar	
9,197,685 B2	11/2015	Soroushian	
9,203,816 B2	12/2015	Brueck et al.	
9,210,481 B2	12/2015	Braness et al.	
9,215,466 B2	12/2015	Zhai et al.	
9,247,311 B2	1/2016	Kiefer	
9,247,312 B2	1/2016	Braness et al.	
9,247,317 B2	1/2016	Shivadas et al.	
9,253,178 B2	2/2016	Blom et al.	
9,264,475 B2	2/2016	Shivadas et al.	
9,294,531 B2	3/2016	Zhang et al.	
9,313,510 B2	4/2016	Shivadas et al.	
9,343,112 B2	5/2016	Amidei et al.	
9,344,517 B2	5/2016	Shivadas et al.	
9,344,721 B2	5/2016	Dikvall	
9,479,805 B2	10/2016	Rothschild et al.	
9,485,546 B2	11/2016	Chen et al.	
9,571,827 B2	2/2017	Su et al.	
9,584,557 B2	2/2017	Panje et al.	
9,584,847 B2	2/2017	Ma et al.	
9,621,522 B2	4/2017	Kiefer et al.	
9,706,259 B2	7/2017	Chan et al.	
9,712,890 B2	7/2017	Shivadas et al.	
9,798,863 B2	10/2017	Grab et al.	
9,813,740 B2	11/2017	Panje et al.	
9,866,878 B2	1/2018	Van Der Schaar et al.	
9,883,204 B2	1/2018	Braness et al.	
9,906,785 B2	2/2018	Naletov et al.	
9,967,189 B2	5/2018	Patel et al.	
9,967,305 B2	5/2018	Braness	
10,212,486 B2	2/2019	Chan et al.	
2001/0030710 A1	10/2001	Werner	
2001/0036355 A1	11/2001	Kelly et al.	
2001/0046299 A1	11/2001	Wasilewski et al.	
2001/0053222 A1	12/2001	Wakao et al.	

Appx67

US 10,484,749 B2

Page 4

(56)   **References Cited**

U.S. PATENT DOCUMENTS

2002/0026560 A1	2/2002	Jordan et al.
2002/0034252 A1	3/2002	Owen et al.
2002/0051494 A1	5/2002	Yamaguchi et al.
2002/0057898 A1	5/2002	Normile
2002/0062313 A1	5/2002	Lee et al.
2002/0076112 A1	6/2002	Devara
2002/0087569 A1	7/2002	Fischer et al.
2002/0091665 A1	7/2002	Beek et al.
2002/0093571 A1	7/2002	Hyodo
2002/0110193 A1	8/2002	Yoo et al.
2002/0116481 A1	8/2002	Lee
2002/0118953 A1	8/2002	Kim
2002/0120934 A1	8/2002	Abrahams et al.
2002/0136298 A1	9/2002	Anantharamu et al.
2002/0143413 A1	10/2002	Fay et al.
2002/0143547 A1	10/2002	Fay et al.
2002/0147980 A1	10/2002	Satoda
2002/0159598 A1	10/2002	Rubinstein et al.
2002/0161462 A1	10/2002	Fay
2002/0180929 A1	12/2002	Tseng et al.
2002/0184159 A1	12/2002	Tadayon et al.
2002/0184515 A1	12/2002	Oho et al.
2002/0191112 A1	12/2002	Akiyoshi et al.
2002/0191959 A1	12/2002	Lin et al.
2002/0191960 A1	12/2002	Fujinami et al.
2003/0001964 A1	1/2003	Masukura et al.
2003/0002578 A1	1/2003	Tsukagoshi et al.
2003/0005442 A1	1/2003	Brodersen et al.
2003/0021296 A1	1/2003	Wee et al.
2003/0031178 A1	2/2003	Haeri
2003/0035488 A1	2/2003	Barrau
2003/0035545 A1	2/2003	Jiang
2003/0035546 A1	2/2003	Jiang et al.
2003/0041257 A1	2/2003	Wee et al.
2003/0061305 A1	3/2003	Copley et al.
2003/0061369 A1	3/2003	Aksu et al.
2003/0065777 A1	4/2003	Mattila et al.
2003/0078930 A1	4/2003	Surcouf et al.
2003/0093799 A1	5/2003	Kauffman et al.
2003/0123855 A1	7/2003	Okada et al.
2003/0128296 A1	7/2003	Lee
2003/0133506 A1	7/2003	Haneda
2003/0152370 A1	8/2003	Otomo et al.
2003/0163824 A1	8/2003	Gordon et al.
2003/0165328 A1	9/2003	Grecia
2003/0174844 A1	9/2003	Candelore
2003/0185302 A1	10/2003	Abrams
2003/0185542 A1	10/2003	McVeigh et al.
2003/0206558 A1	11/2003	Parkkinen et al.
2003/0216922 A1	11/2003	Gonzales et al.
2003/0229900 A1	12/2003	Reisman
2003/0231863 A1	12/2003	Eerenberg et al.
2003/0231867 A1	12/2003	Gates et al.
2003/0233464 A1	12/2003	Walpole et al.
2003/0236836 A1	12/2003	Borthwick
2003/0236907 A1	12/2003	Stewart et al.
2004/0006701 A1	1/2004	Kresina
2004/0021684 A1	2/2004	Millner
2004/0024688 A1	2/2004	Bi et al.
2004/0025180 A1	2/2004	Begeja et al.
2004/0031058 A1	2/2004	Reisman
2004/0039916 A1	2/2004	Aldis et al.
2004/0047614 A1	3/2004	Green
2004/0052501 A1	3/2004	Tam
2004/0071453 A1	4/2004	Valderas
2004/0081333 A1	4/2004	Grab et al.
2004/0081434 A1	4/2004	Jung et al.
2004/0084035 A1	5/2004	Newton
2004/0093618 A1	5/2004	Baldwin et al.
2004/0101142 A1*	5/2004	Nasypny G06F 21/602
		380/278
2004/0105549 A1	6/2004	Suzuki et al.
2004/0114687 A1	6/2004	Ferris et al.
2004/0117347 A1	6/2004	Seo et al.
2004/0136698 A1	7/2004	Mock
2004/0139335 A1	7/2004	Diamand et al.
2004/0143760 A1	7/2004	Alkove et al.
2004/0146276 A1	7/2004	Ogawa
2004/0158878 A1	8/2004	Ratnakar et al.
2004/0184534 A1	9/2004	Wang
2004/0184616 A1	9/2004	Morten et al.
2004/0202320 A1	10/2004	Amini et al.
2004/0217971 A1	11/2004	Kim
2004/0243488 A1*	12/2004	Yamamoto G06F 21/10
		705/30
2004/0255115 A1	12/2004	DeMello et al.
2004/0255236 A1	12/2004	Collart
2005/0004875 A1	1/2005	Kontio et al.
2005/0005025 A1	1/2005	Harville et al.
2005/0015797 A1	1/2005	Noblecourt et al.
2005/0038826 A1	2/2005	Bae et al.
2005/0055399 A1	3/2005	Savchuk
2005/0071280 A1	3/2005	Irwin et al.
2005/0108320 A1	5/2005	Lord et al.
2005/0114534 A1	5/2005	Lee
2005/0114896 A1	5/2005	Hug
2005/0132208 A1*	6/2005	Hug G06F 21/10
		713/189
2005/0149450 A1	7/2005	Stefik et al.
2005/0180641 A1	8/2005	Clark
2005/0183120 A1	8/2005	Jain et al.
2005/0193070 A1	9/2005	Brown et al.
2005/0193322 A1	9/2005	Lamkin et al.
2005/0196147 A1	9/2005	Seo et al.
2005/0204289 A1	9/2005	Mohammed et al.
2005/0207442 A1	9/2005	Van Zoest et al.
2005/0207578 A1	9/2005	Matsuyama et al.
2005/0254508 A1	11/2005	Aksu et al.
2005/0273695 A1	12/2005	Schnurr
2005/0275656 A1	12/2005	Corbin et al.
2006/0015580 A1	1/2006	Gabriel et al.
2006/0026294 A1	2/2006	Virdi et al.
2006/0026302 A1	2/2006	Bennett et al.
2006/0036549 A1	2/2006	Wu
2006/0037057 A1	2/2006	Xu
2006/0052095 A1	3/2006	Vazvan
2006/0053080 A1	3/2006	Edmonson et al.
2006/0064605 A1	3/2006	Giobbi
2006/0078301 A1	4/2006	Ikeda et al.
2006/0093320 A1	5/2006	Hallberg et al.
2006/0120378 A1	6/2006	Usuki et al.
2006/0129909 A1	6/2006	Butt et al.
2006/0165233 A1*	7/2006	Nonaka G06F 21/10
		380/44
2006/0168639 A1	7/2006	Gan et al.
2006/0173887 A1	8/2006	Breitfeld et al.
2006/0179239 A1	8/2006	Fluhr
2006/0181965 A1	8/2006	Collart
2006/0235804 A1	10/2006	Qian
2006/0245727 A1	11/2006	Nakano et al.
2006/0259588 A1	11/2006	Lerman et al.
2006/0263056 A1	11/2006	Lin et al.
2006/0267986 A1	11/2006	Bae
2006/0274835 A1	12/2006	Hamilton et al.
2006/0294164 A1	12/2006	Armangau et al.
2007/0005333 A1	1/2007	Setiohardjo et al.
2007/0031110 A1	2/2007	Rijckaert
2007/0033419 A1	2/2007	Kocher et al.
2007/0044010 A1	2/2007	Sull et al.
2007/0047901 A1	3/2007	Ando et al.
2007/0053513 A1	3/2007	Hoffberg
2007/0058928 A1	3/2007	Naito et al.
2007/0067622 A1*	3/2007	Nakano H04L 9/0822
		713/163
2007/0083617 A1	4/2007	Chakrabarti et al.
2007/0086528 A1	4/2007	Mauchly et al.
2007/0100757 A1	5/2007	Rhoads
2007/0133603 A1	6/2007	Weaver
2007/0136817 A1	6/2007	Nguyen
2007/0140647 A1	6/2007	Kusunoki et al.
2007/0154165 A1	7/2007	Hemmeryckz-Deleersnijder et al.
2007/0168541 A1	7/2007	Gupta et al.
2007/0168542 A1	7/2007	Gupta et al.
2007/0178933 A1	8/2007	Nelson

US 10,484,749 B2

Page 5

(56)   **References Cited**

             U.S. PATENT DOCUMENTS

2007/0180125 A1	8/2007	Knowles et al.
2007/0185982 A1	8/2007	Nakanowatari et al.
2007/0192810 A1	8/2007	Pritchett et al.
2007/0217339 A1	9/2007	Zhao
2007/0217759 A1	9/2007	Dodd
2007/0234391 A1	10/2007	Hunter et al.
2007/0239839 A1	10/2007	Buday et al.
2007/0255940 A1	11/2007	Ueno
2007/0256141 A1*	11/2007	Nakano G06F 21/16
		726/27
2007/0271317 A1	11/2007	Carmel et al.
2007/0271385 A1	11/2007	Davis et al.
2007/0274679 A1	11/2007	Yahata et al.
2007/0277219 A1	11/2007	Toebes et al.
2007/0277234 A1	11/2007	Bessonov et al.
2007/0280298 A1	12/2007	Hearn et al.
2007/0288745 A1	12/2007	Kwan
2007/0292107 A1	12/2007	Yahata et al.
2007/0297422 A1	12/2007	Matsuo et al.
2008/0005175 A1	1/2008	Bourke et al.
2008/0008319 A1*	1/2008	Poirier H04L 9/0866
		380/228
2008/0008455 A1	1/2008	De Lange et al.
2008/0043832 A1	2/2008	Barkley et al.
2008/0046718 A1	2/2008	Grab
2008/0066099 A1	3/2008	Brodersen et al.
2008/0066181 A1	3/2008	Haveson et al.
2008/0077592 A1	3/2008	Brodie et al.
2008/0086456 A1	4/2008	Rasanen et al.
2008/0086747 A1	4/2008	Rasanen et al.
2008/0101466 A1	5/2008	Swenson et al.
2008/0104633 A1	5/2008	Noblecourt et al.
2008/0120330 A1	5/2008	Reed et al.
2008/0120342 A1	5/2008	Reed et al.
2008/0120389 A1	5/2008	Bassali et al.
2008/0126248 A1	5/2008	Lee et al.
2008/0137541 A1	6/2008	Agarwal et al.
2008/0137736 A1	6/2008	Richardson et al.
2008/0151817 A1	6/2008	Fitchett
2008/0162949 A1*	7/2008	Sato G06F 21/14
		713/194
2008/0172441 A1	7/2008	Speicher et al.
2008/0187283 A1	8/2008	Takahashi
2008/0192818 A1	8/2008	DiPietro et al.
2008/0195664 A1	8/2008	Maharajh et al.
2008/0195744 A1	8/2008	Bowra et al.
2008/0201705 A1	8/2008	Wookey
2008/0205860 A1	8/2008	Holtman
2008/0209534 A1	8/2008	Keronen et al.
2008/0219449 A1*	9/2008	Ball G06F 21/80
		380/277
2008/0240144 A1	10/2008	Kruse et al.
2008/0256105 A1	10/2008	Nogawa et al.
2008/0263354 A1	10/2008	Beuque et al.
2008/0279535 A1	11/2008	Haque et al.
2008/0294453 A1	11/2008	Baird-Smith et al.
2008/0298358 A1	12/2008	John et al.
2008/0310454 A1	12/2008	Bellwood et al.
2008/0310496 A1	12/2008	Fang
2009/0031220 A1	1/2009	Tranchant et al.
2009/0037959 A1	2/2009	Suh et al.
2009/0048852 A1	2/2009	Burns et al.
2009/0055546 A1	2/2009	Jung et al.
2009/0060452 A1	3/2009	Chaudhri
2009/0064341 A1	3/2009	Hartung et al.
2009/0066839 A1	3/2009	Jung et al.
2009/0097644 A1	4/2009	Haruki
2009/0132599 A1	5/2009	Soroushian et al.
2009/0132721 A1	5/2009	Soroushian et al.
2009/0132824 A1	5/2009	Terada et al.
2009/0136216 A1	5/2009	Soroushian et al.
2009/0150557 A1	6/2009	Wormley et al.
2009/0165148 A1	6/2009	Frey et al.
2009/0168795 A1	7/2009	Segel et al.
2009/0169181 A1	7/2009	Priyadarshi et al.

2009/0172201 A1	7/2009	Carmel et al.
2009/0178090 A1	7/2009	Oztaskent
2009/0196139 A1	8/2009	Bates et al.
2009/0201988 A1	8/2009	Gazier et al.
2009/0217317 A1	8/2009	White et al.
2009/0226148 A1	9/2009	Nesvadba et al.
2009/0228395 A1	9/2009	Wegner et al.
2009/0265737 A1	10/2009	Issa et al.
2009/0268905 A1*	10/2009	Matsushima G06F 21/10
		380/200
2009/0276636 A1	11/2009	Grab et al.
2009/0290706 A1	11/2009	Amini et al.
2009/0290708 A1	11/2009	Schneider et al.
2009/0293116 A1	11/2009	DeMello
2009/0303241 A1	12/2009	Priyadarshi et al.
2009/0307258 A1	12/2009	Priyadarshi et al.
2009/0307267 A1	12/2009	Chen et al.
2009/0310819 A1	12/2009	Hatano
2009/0310933 A1	12/2009	Lee
2009/0313544 A1	12/2009	Wood et al.
2009/0313564 A1	12/2009	Rottler et al.
2009/0316783 A1	12/2009	Au et al.
2009/0328124 A1	12/2009	Khouzam et al.
2009/0328228 A1	12/2009	Schnell
2010/0040351 A1	2/2010	Toma et al.
2010/0057928 A1	3/2010	Kapoor et al.
2010/0058405 A1	3/2010	Ramakrishnan et al.
2010/0074324 A1	3/2010	Qian et al.
2010/0074333 A1	3/2010	Au et al.
2010/0083322 A1	4/2010	Rouse
2010/0094969 A1	4/2010	Zuckerman et al.
2010/0095121 A1	4/2010	Shetty et al.
2010/0106968 A1	4/2010	Mori et al.
2010/0107260 A1	4/2010	Orrell et al.
2010/0111192 A1	5/2010	Graves
2010/0138903 A1	6/2010	Medvinsky
2010/0142917 A1	6/2010	Isaji
2010/0158109 A1	6/2010	Dahlby et al.
2010/0161825 A1	6/2010	Ronca et al.
2010/0166060 A1	7/2010	Ezure et al.
2010/0186092 A1	7/2010	Takechi et al.
2010/0189183 A1	7/2010	Gu et al.
2010/0218208 A1	8/2010	Holden
2010/0228795 A1	9/2010	Hahn
2010/0235472 A1	9/2010	Sood et al.
2010/0250532 A1	9/2010	Soroushian et al.
2010/0290761 A1	11/2010	Drake et al.
2010/0299522 A1	11/2010	Khambete et al.
2010/0306249 A1	12/2010	Hill et al.
2010/0313225 A1	12/2010	Cholas et al.
2010/0313226 A1	12/2010	Cholas et al.
2010/0319014 A1	12/2010	Lockett et al.
2010/0319017 A1	12/2010	Cook
2010/0332595 A1	12/2010	Fullagar et al.
2011/0002381 A1	1/2011	Yang et al.
2011/0016225 A1	1/2011	Park et al.
2011/0047209 A1	2/2011	Lindholm et al.
2011/0055585 A1	3/2011	Lee
2011/0060808 A1	3/2011	Martin et al.
2011/0066673 A1	3/2011	Outlaw
2011/0067057 A1	3/2011	Karaoguz et al.
2011/0078440 A1	3/2011	Feng et al.
2011/0080940 A1	4/2011	Bocharov
2011/0082924 A1	4/2011	Gopalakrishnan
2011/0096828 A1	4/2011	Chen et al.
2011/0107379 A1	5/2011	Lajoie et al.
2011/0116772 A1	5/2011	Kwon et al.
2011/0126191 A1	5/2011	Hughes et al.
2011/0129011 A1	6/2011	Cilli et al.
2011/0135090 A1	6/2011	Chan et al.
2011/0138018 A1	6/2011	Raveendran et al.
2011/0142415 A1	6/2011	Rhyu
2011/0145726 A1	6/2011	Wei et al.
2011/0149753 A1	6/2011	Bapst et al.
2011/0150100 A1	6/2011	Abadir
2011/0153785 A1	6/2011	Minborg et al.
2011/0153835 A1	6/2011	Rimac et al.
2011/0184738 A1	7/2011	Kalisky et al.
2011/0191439 A1	8/2011	Dazzi et al.

US 10,484,749 B2

Page 6

(56)   **References Cited**

         U.S. PATENT DOCUMENTS

2011/0191803 A1	8/2011	Baldwin et al.
2011/0197237 A1	8/2011	Turner
2011/0197267 A1	8/2011	Gravel et al.
2011/0213827 A1	9/2011	Kaspar et al.
2011/0222786 A1	9/2011	Carmel et al.
2011/0225302 A1	9/2011	Park et al.
2011/0225315 A1	9/2011	Wexler et al.
2011/0225417 A1	9/2011	Maharajh et al.
2011/0239078 A1	9/2011	Luby et al.
2011/0246657 A1	10/2011	Glow
2011/0246659 A1	10/2011	Bouazizi
2011/0252118 A1	10/2011	Pantos et al.
2011/0264530 A1	10/2011	Santangelo et al.
2011/0268178 A1	11/2011	Park et al.
2011/0276695 A1	11/2011	Maldaner et al.
2011/0283012 A1	11/2011	Melnyk
2011/0291723 A1	12/2011	Hashimoto
2011/0302319 A1	12/2011	Ha et al.
2011/0305273 A1	12/2011	He et al.
2011/0314176 A1	12/2011	Frojdh et al.
2011/0314500 A1	12/2011	Gordon
2012/0005368 A1	1/2012	Knittle et al.
2012/0017282 A1	1/2012	Kang et al.
2012/0023251 A1	1/2012	Pyle et al.
2012/0036365 A1	2/2012	Kyslov et al.
2012/0036544 A1	2/2012	Chen et al.
2012/0066360 A1	3/2012	Ghosh
2012/0093214 A1	4/2012	Urbach
2012/0114302 A1	5/2012	Randall
2012/0124191 A1	5/2012	Lyon
2012/0137336 A1	5/2012	Applegate et al.
2012/0144117 A1	6/2012	Weare et al.
2012/0144445 A1	6/2012	Bonta et al.
2012/0166633 A1	6/2012	Baumback et al.
2012/0170642 A1	7/2012	Braness et al.
2012/0170643 A1	7/2012	Soroushian et al.
2012/0170906 A1	7/2012	Soroushian et al.
2012/0170915 A1	7/2012	Braness et al.
2012/0173751 A1	7/2012	Braness et al.
2012/0177101 A1	7/2012	Van Der Schaar
2012/0179834 A1	7/2012	Van Der Schaar et al.
2012/0201475 A1	8/2012	Carmel et al.
2012/0201476 A1	8/2012	Carmel et al.
2012/0233345 A1	9/2012	Hannuksela
2012/0240176 A1	9/2012	Ma et al.
2012/0254455 A1	10/2012	Adimatyam et al.
2012/0260277 A1	10/2012	Kosciewicz
2012/0263434 A1	10/2012	Wainner et al.
2012/0265562 A1	10/2012	Daouk et al.
2012/0278496 A1	11/2012	Hsu
2012/0289147 A1	11/2012	Raleigh et al.
2012/0294355 A1	11/2012	Holcomb et al.
2012/0297039 A1	11/2012	Acuna et al.
2012/0307883 A1	12/2012	Graves
2012/0311094 A1	12/2012	Biderman et al.
2012/0314778 A1	12/2012	Salustri et al.
2012/0317235 A1	12/2012	Nguyen et al.
2013/0007223 A1	1/2013	Luby et al.
2013/0013730 A1	1/2013	Li et al.
2013/0019107 A1	1/2013	Grab et al.
2013/0019273 A1	1/2013	Ma et al.
2013/0041808 A1	2/2013	Pham et al.
2013/0044821 A1	2/2013	Braness et al.
2013/0046849 A1	2/2013	Wolf
2013/0046902 A1	2/2013	Villegas Nuñez et al.
2013/0051554 A1	2/2013	Braness et al.
2013/0054958 A1	2/2013	Braness et al.
2013/0055084 A1	2/2013	Soroushian et al.
2013/0058480 A1	3/2013	Ziskind et al.
2013/0061040 A1	3/2013	Kiefer et al.
2013/0061045 A1	3/2013	Kiefer et al.
2013/0064466 A1	3/2013	Carmel et al.
2013/0066838 A1	3/2013	Singla et al.
2013/0094565 A1	4/2013	Yang et al.
2013/0097309 A1	4/2013	Ma et al.
2013/0114944 A1	5/2013	Soroushian et al.
2013/0124859 A1	5/2013	Pestoni et al.
2013/0128962 A1	5/2013	Rajagopalan et al.
2013/0152767 A1	6/2013	Katz et al.
2013/0166580 A1	6/2013	Maharajh
2013/0166765 A1	6/2013	Kaufman
2013/0166906 A1	6/2013	Swaminathan et al.
2013/0170561 A1	7/2013	Hannuksela
2013/0170764 A1	7/2013	Carmel et al.
2013/0173513 A1	7/2013	Chu et al.
2013/0179199 A1	7/2013	Ziskind et al.
2013/0179992 A1	7/2013	Ziskind et al.
2013/0182952 A1	7/2013	Carmel et al.
2013/0196292 A1	8/2013	Brennen et al.
2013/0212228 A1	8/2013	Butler
2013/0223812 A1	8/2013	Rossi
2013/0226578 A1	8/2013	Bolton et al.
2013/0226635 A1	8/2013	Fisher
2013/0227081 A1	8/2013	Luby et al.
2013/0227122 A1	8/2013	Gao
2013/0301424 A1	11/2013	Kotecha et al.
2013/0311670 A1	11/2013	Tarbox et al.
2013/0329781 A1	12/2013	Su et al.
2014/0003516 A1	1/2014	Soroushian
2014/0019593 A1	1/2014	Reznik et al.
2014/0037620 A1	2/2014	Ferree et al.
2014/0052823 A1	2/2014	Gavade et al.
2014/0059156 A1	2/2014	Freeman, II et al.
2014/0096171 A1	4/2014	Shivadas et al.
2014/0101722 A1	4/2014	Moore
2014/0115650 A1	4/2014	Zhang et al.
2014/0119432 A1	5/2014	Wang et al.
2014/0140396 A1	5/2014	Wang et al.
2014/0140417 A1	5/2014	Shaffer et al.
2014/0143301 A1	5/2014	Watson et al.
2014/0143431 A1	5/2014	Watson et al.
2014/0143440 A1	5/2014	Ramamurthy et al.
2014/0177734 A1	6/2014	Carmel et al.
2014/0189065 A1	7/2014	Van Der Schaar et al.
2014/0201382 A1	7/2014	Shivadas et al.
2014/0211840 A1	7/2014	Butt et al.
2014/0211859 A1	7/2014	Carmel et al.
2014/0241420 A1	8/2014	Orton-jay et al.
2014/0241421 A1	8/2014	Orton-jay et al.
2014/0247869 A1	9/2014	Su et al.
2014/0250473 A1	9/2014	Braness et al.
2014/0258714 A1	9/2014	Grab
2014/0269927 A1	9/2014	Naletov et al.
2014/0269936 A1	9/2014	Shivadas et al.
2014/0280763 A1	9/2014	Grab et al.
2014/0297804 A1	10/2014	Shivadas et al.
2014/0297881 A1	10/2014	Shivadas et al.
2014/0355668 A1	12/2014	Shoham et al.
2014/0359678 A1	12/2014	Shivadas et al.
2014/0359679 A1	12/2014	Shivadas et al.
2014/0359680 A1	12/2014	Shivadas et al.
2014/0376720 A1	12/2014	Chan et al.
2015/0006662 A1	1/2015	Braness
2015/0026677 A1	1/2015	Stevens et al.
2015/0049957 A1	2/2015	Shoham et al.
2015/0063693 A1	3/2015	Carmel et al.
2015/0067715 A1	3/2015	Koat et al.
2015/0104153 A1	4/2015	Braness et al.
2015/0117836 A1	4/2015	Amidei et al.
2015/0117837 A1	4/2015	Amidei et al.
2015/0139419 A1	5/2015	Kiefer et al.
2015/0188758 A1	7/2015	Amidei et al.
2015/0188842 A1	7/2015	Amidei et al.
2015/0188921 A1	7/2015	Amidei et al.
2015/0189017 A1	7/2015	Amidei et al.
2015/0189373 A1	7/2015	Amidei et al.
2015/0288996 A1	10/2015	Van Der Schaar et al.
2015/0334435 A1	11/2015	Shivadas et al.
2015/0373421 A1	12/2015	Chan et al.
2016/0070890 A1	3/2016	Grab et al.
2016/0112382 A1	4/2016	Kiefer et al.
2016/0149981 A1	5/2016	Shivadas et al.
2016/0219303 A1	7/2016	Braness et al.
2017/0214947 A1	7/2017	Kiefer et al.

Appx70

US 10,484,749 B2

Page 7

(56)   **References Cited**

U.S. PATENT DOCUMENTS

2017/0280203	A1	9/2017	Chan et al.
2018/0007451	A1	1/2018	Shivadas et al.
2018/0060543	A1	3/2018	Grab et al.
2018/0131980	A1	5/2018	Van Der Schaar et al.
2018/0220153	A1	8/2018	Braness et al.
2019/0020907	A1	1/2019	Kiefer et al.
2019/0045234	A1	2/2019	Kiefer et al.

FOREIGN PATENT DOCUMENTS

CN	1221284	A	6/1999
CN	1723696		1/2006
EP	757484	A2	2/1997
EP	813167	A2	12/1997
EP	0936812	A1	8/1999
EP	1056273	A2	11/2000
EP	1187483	A2	3/2002
EP	1420580	A1	5/2004
EP	1553779	A1	7/2005
EP	1657835	A1	5/2006
EP	1718074	A1	11/2006
EP	2486517	A1	8/2012
EP	2486727	A1	8/2012
EP	2507995	A1	10/2012
EP	2564354	A1	3/2013
EP	2616991		7/2013
EP	2617192		7/2013
EP	2661696	A1	11/2013
EP	2661875	A1	11/2013
EP	2661895	A2	11/2013
EP	2486727	A4	3/2014
EP	2564354	A4	3/2014
EP	2616991	A4	3/2014
EP	2617192	A4	3/2014
EP	2716048	A1	4/2014
EP	2721826	A1	4/2014
EP	2486517		6/2014
EP	2751990		7/2014
EP	2807821		12/2014
EP	2751990	A4	4/2015
HK	1125765	A	8/2009
JP	08046902	A	2/1996
JP	08111842	A	4/1996
JP	08163488	A	6/1996
JP	08287613	A	11/1996
JP	09037225	A	2/1997
JP	11164307	A	6/1999
JP	11275576	A	10/1999
JP	11328929	A	11/1999
JP	2000201343	A	7/2000
JP	02001043668	A	2/2001
JP	2001209726	A	8/2001
JP	2001346165	A	12/2001
JP	2002164880	A	6/2002
JP	2002170363	A	6/2002
JP	2002518898	A	6/2002
JP	2002218384	A	8/2002
JP	2003179597	A	6/2003
JP	2003250113	A	9/2003
JP	2004013823	A	1/2004
JP	2004515941	A	5/2004
JP	2004172830	A	6/2004
JP	2004187161	A	7/2004
JP	2004234128	A	8/2004
JP	2005027153		1/2005
JP	2005080204	A	3/2005
JP	2006155500	A	6/2006
JP	2006524007	A	10/2006
JP	2007036666	A	2/2007
JP	2007174375	A	7/2007
JP	2007235690	A	9/2007
JP	2007535881	A	12/2007
JP	2008235999	A	10/2008
JP	2009530917	A	8/2009
JP	2013513298	A	4/2013

JP	5200204	B2	6/2013
JP	2014506430	A	3/2014
JP	5723888	B2	4/2015
JP	2015167357	A	9/2015
JP	6038805	B2	12/2016
JP	6078574	B2	1/2017
JP	2017063453		3/2017
KR	100221423	B1	9/1999
KR	2002013664		2/2002
KR	1020020064888	A	8/2002
KR	100669616	B1	1/2007
KR	1020130133830		12/2013
KR	101874907	B1	7/2018
SG	146026		12/2010
WO	1995015660	A1	6/1995
WO	1996013121		5/1996
WO	1997031445	A3	4/1998
WO	1999010836	A1	3/1999
WO	1999065239	A2	12/1999
WO	0104892	A1	1/2001
WO	2001031497	A1	5/2001
WO	2001050732	A2	7/2001
WO	2001065762	A2	9/2001
WO	2002001880	A1	1/2002
WO	2002008948	A2	1/2002
WO	2002035832	A2	5/2002
WO	2002037210	A2	5/2002
WO	2002054196	A2	7/2002
WO	2003030000	A1	4/2003
WO	2003096136	A2	11/2003
WO	2004054247	A1	6/2004
WO	2004097811	A1	11/2004
WO	2004102571	A1	11/2004
WO	2006018843	A2	2/2006
WO	20060012398	A2	2/2006
WO	2006018843	A3	12/2006
WO	2007044590	A2	4/2007
WO	2007113836	A2	10/2007
WO	2008010275	A1	1/2008
WO	2008042242	A2	4/2008
WO	2008086313	A1	7/2008
WO	2007113836	A3	11/2008
WO	2008135932	A2	11/2008
WO	2007113836	B1	12/2008
WO	2009065137	A1	5/2009
WO	20100005673		1/2010
WO	2010060106	A1	5/2010
WO	2010080911	A1	7/2010
WO	2010089962	A1	8/2010
WO	2010108053	A1	9/2010
WO	2010111261	A1	9/2010
WO	2010122447	A1	10/2010
WO	2010147878	A1	12/2010
WO	2011042898	A1	4/2011
WO	2011042900	A1	4/2011
WO	2011068668	A1	6/2011
WO	2011103364	A1	8/2011
WO	2011132184	A1	10/2011
WO	2011135558	A1	11/2011
WO	2012035533	A2	3/2012
WO	2012035534	A2	3/2012
WO	2012035534	A3	7/2012
WO	2012094171	A1	7/2012
WO	20120094181	A2	7/2012
WO	20120094189	A1	7/2012
WO	2012035533	A3	8/2012
WO	2012162806	A1	12/2012
WO	2012171113	A1	12/2012
WO	2013030833	A1	3/2013
WO	2013032518	A2	3/2013
WO	2013103986	A2	7/2013
WO	2013111126	A2	8/2013
WO	2013111126	A3	8/2013
WO	2013032518	A3	9/2013
WO	2013144942	A1	10/2013
WO	2014145901	A1	9/2014
WO	2014193996	A2	12/2014
WO	2014193996	A3	2/2015
WO	2015031982	A1	3/2015

Appx71

US 10,484,749 B2

Page 8

(56)   **References Cited**

FOREIGN PATENT DOCUMENTS

OTHER PUBLICATIONS

International Preliminary Report on Patentability for International Application No. PCT/US2011/068276, dated Mar. 4, 2014, 23 pgs.
International Preliminary Report on Patentability for International Application PCT/US2011/067167, dated Feb. 25, 2014, 8 pgs.
International Preliminary Report on Patentability for International Application PCT/US2013/043181, dated Dec. 31, 2014, dated Jan. 8, 2015, 11 pgs.
International Preliminary Report on Patentability for International Application PCT/US2014/039852, dated Dec. 1, 2015, dated Dec. 5, 2015, 8 pgs.
International Search Report and Written Opinion for International Application No. PCT/US07/63950, Completed Feb. 19, 2008, dated Mar. 19, 2008, 9 pgs.
International Search Report and Written Opinion for International Application No. PCT/US08/87999, Completed Feb. 7, 2009, dated Mar. 19, 2009, 6 pgs.
International Search Report and Written Opinion for International Application No. PCT/US09/46588, Completed Jul. 13, 2009, dated Jul. 23, 2009, 7 pgs.
International Search Report and Written Opinion for International Application No. PCT/US2004/041667, Completed May 24, 2007, dated Jun. 20, 2007, 6 pgs.
International Search Report and Written Opinion for International Application No. PCT/US2005/025845, Completed Feb. 5, 2007, dated May 10, 2007, 8 pgs.
International Search Report and Written Opinion for International Application No. PCT/US2008/083816, Completed Jan. 10, 2009, dated Jan. 22, 2009, 7 pgs.
International Search Report and Written Opinion for International Application No. PCT/US2010/020372, Completed Feb. 10, 2009, dated Mar. 1, 2010, 8 pgs.
International Search Report and Written Opinion for International Application No. PCT/US2010/56733, Completed Jan. 3, 2011, dated Jan. 14, 2011, 9 pgs.
International Search Report and Written Opinion for International Application No. PCT/US2011/067243, International Filing Date Dec. 23, 2011, Search Completed Apr. 24, 2012, dated May 8, 2012, 8 pgs.
International Search Report and Written Opinion for International Application No. PCT/US2013/043181, Completed Nov. 27, 2013, dated Dec. 6, 2013, 12 pgs.
International Search Report and Written Opinion for International Application PCT/US14/30747, Completed Jul. 30, 2014, dated Aug 22, 2014, 7 pgs.
International Search Report and Written Opinion for International Application PCT/US14/39852, Completed Oct. 21, 2014, dated Dec. 5, 2014, 11 pgs.
International Search Report and Written Opinion for International Application PCT/US2011/066927, Completed Apr. 3, 2012, dated Apr. 20, 2012, 14 pgs.
International Search Report and Written Opinion for International Application PCT/US2011/067167, Completed Jun. 19, 2012, dated Jul. 2, 2012, 11 pgs.
International Search Report and Written Opinion for International Application PCT/US2011/068276, Completed Jun. 19, 2013, dated Jul. 8, 2013, 24 pgs.
International Search Report and Written Opinion for PCT/US2013/020572, International Filing Date Jan. 7, 2013, Search Completed Mar. 19, 2013, dated Apr. 29, 2013, 10 pgs.
International Telecommunication Union, Telecommunication Standardization Sector of ITU, H.233, Line Transmission of Non-Telephone Signals, Confidentiality System for Audiovisual Services, ITU-T Recommendation H.233, Mar. 1993, 18 pgs.
ITS International, "Fleet System Opts for Mobile Server", Aug. 26, 1999, Printed on Oct. 21, 2011 from http://www.itsinternational.com/News/article.cfm?recordID=547, 2 pgs.

Lifehacker—Boxqueue Bookmarklet Saves Videos for Later Boxee Watching, printed Jun. 16, 2009 from http://feeds.gawker.com/~r/lifehacker/full/~3/OHvDmrlgZZc/boxqueue-bookmarklet-saves-videos-for-late-boxee-watching, 2 pgs.
Linksys Wireless-B Media Adapter Reviews, printed May 4, 2007 from http://reviews.cnet.com/Linksys_Wireless_B_Media_Adapter/4505-6739_7-30421900.html?tag=box, 5 pgs.
Linksys, KISS DP-500, printed May 4, 2007 from http://www.kiss-technology.com/?p=dp500, 2 pgs.
LINKSYS®: "Enjoy your digital music and pictures on your home entertainment center, without stringing wires!", Model No. WMA 11B, printed May 9, 2007 from http://www.linksys.com/servlet/Satellite?c=L_Product_C2&childpagename=US/Layout&cid=1115416830950&p.
Microsoft Corporation, "Chapter 8, Multimedia File Formats" 1991, Microsoft Windows Multimedia Programmer's Reference, 3 cover pgs, pp. 8-1 to 8-20.
Microsoft Media Platform: Player Framework, "Microsoft Media Platform: Player Framework v2.5 (formerly Silverlight Media Framework)", May 3, 2011, 2 pages.
Microsoft Media Platform: Player Framework, "Silverlight Media Framework v1.1", Jan. 2010, 2 pages.
Microsoft Windows® XP Media Center Edition 2005, Frequently asked Questions, printed May 4, 2007 from http://www.microsoft.com/windowsxp/mediacenter/evaluation/faq.mspx.
Microsoft Windows® XP Media Center Edition 2005: Features, printed May 9, 2007, from http://www.microsoft.com/windowsxp/mediacenter/evaluation/features.mspx, 4 pgs.
Office Action for Chinese Patent Application No. CN200880127596.4, dated May 6, 2014, 8 pgs.
Office Action for U.S. Appl. No. 13/223,210, dated Apr. 30, 2015, 14 pgs.
Office Action for U.S. Appl. No. 14/564,003, dated Apr. 17, 2015, 28 pgs.
Open DML AVI-M-JPEG File Format Subcommittee, "Open DML AVI File Format Extensions", Version 1.02, Feb. 28, 1996, 29 pgs.
PC world.com, Future Gear: PC on the HiFi, and the TV, from http://www.pcworld.com/article/id,108818-page,1/article.html, printed May 4, 2007, from IDG Networks, 2 pgs.
Qtv—About BroadQ, printed May 11, 2009 from http://www.broadq.com/en/about.php, 1 pg.
Supplementary European Search Report for Application No. EP 04813918, Search Completed Dec. 19, 2012, 3 pgs.
Supplementary European Search Report for Application No. EP 10729513, completed Dec. 9, 2013, 4 pgs.
Supplementary European Search Report for International Application No. PCT/US2007063950, Report Completed Jan. 25, 2013, 8 pgs.
Windows Media Center Extender for Xbox, printed May 9, 2007 from http://www.xbox.com/en-US/support/systemuse/xbox/console/mediacenterextender.htm, 2 pgs.
Windows® XP Media Center Edition 2005, "Experience more entertainment", retrieved from http://download.microsoft.com/download/c/9/a/c9a7000a-66b3-455b-860b-1c16f2eecfec/MCE.pdf on May 9, 2007, 2 pgs.
Invitation to Pay Add'l Fees Rcvd for International Application PCT/US14/39852, dated Sep 25, 2014, 2 pgs.
3GPP TS 26.247, V1.3.0, 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects Transparent end-to-end Packet-switches Streaming Services (PSS);, Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH) (Release 10), Mar. 2011, 72 pgs.
"Adaptive Streaming Comparison", Jan. 28, 2010, 5 pgs.
"Best Practices for Multi-Device Transcoding", Kaltura Open Source Video, Printed on Nov. 27, 2013 from knowledge.kaltura.com/best-practices-multi-device-transcoding, 13 pgs.
"Container format (digital)", printed Aug. 22, 2009 from http://en.wikipedia.org/wiki/Container_format (digital), 4 pgs.
"Diagram | Matroska", Dec. 17, 2010, Retrieved from http://web.archive.org/web/201 01217114656/http:I/matroska.org/technical/diagram/index.html on Jan. 29, 2016, 5 pages, Dec. 17, 2010.

Appx72

US 10,484,749 B2

Page 9

(56)   References Cited

OTHER PUBLICATIONS

"Draft CR: Trick Mode for HTTP Streaming", 3GPP TSG-SA4 Meeting #58, Apr. 26-30, 2010, Vancouver, Canada, S4-100237, 3 pgs.
"DVD—MPeg differences", printed Jul. 2, 2009 from http://dvd.sourceforge.net/dvdinfo/dvdmpeg.html, 1 pg.
"DVD subtitles", sam.zoy.org/writings/dvd/subtitles, dated Jan. 9, 2001, printed Jul. 2, 2009, 4 pgs.
"Final Committee Draft of MPEG-4 streaming text format", International Organisation for Standardisation, Feb. 2004, 22 pgs.
RGB Networks, "Comparing Adaptive HTTP Streaming Technologies", Nov. 2011, Retrieved from: http://btreport.net/wp-content/uploads/2012/02/RGB-Adaptive-HTTP-Streaming-Comparison-1211-01.pdf, 20 pgs.
Rosenberg et al., "Indicating User Agent Capabilities in the Session Initiation Protocol (SIP)", Network Working Group, RFC 3840, Aug. 2004, 36 pgs.
Schulzrinne, H, "Real Time Streaming Protocol 2.0 (RTSP): draft-ietfmmusic-rfc2326bis-27", MMUSIC Working Group of the Internet Engineering Task Force (IETF), (presented in two parts), Mar. 9, 2011, 296 pages.
Siglin, "HTTP Streaming: What You Need to Know", streamingmedia.com, 2010, 15 pages.
Siglin, "Unifying Global Video Strategies, MP4 File Fragmentation for Broadcast, Mobile and Web Delivery", Nov. 16, 2011, 16 pgs.
Silvio, "Adaptive HTTP streaming for open codecs", Oct. 9, 2010, Retrieved on: Mar. 2, 2018.
Tan, Yap-Peng et al., "Video transcoding for fast forward/reverse video playback", IEEE ICIP, 2002, pp. I-713 to I-716.
Taxan, "AVel LinkPlayer2 for Consumer", I-O Data USA—Products—Home Entertainment, printed May 4, 2007 from http://www.iodata.com/usa/products/products.php?cat=HNP&sc=AVEL&pld=AVLP2/DVDLA&ts=2&tsc, 1 pg.
Tripathi et al., "Improving Multimedia Streaming with Content-Aware Video Scaling", Retrieved from: http://digitalcommons.wpi.edu/computerscience-pubs/96, 2001, 17 pgs.
Unknown, "AVI RIFF File Reference (Direct X 8.1 C++ Archive)", printed from http://msdn.microsoft.com/archive/en-us/dx81_c/directx_cpp/htm/avirifffilereference.asp?fr . . . on Mar. 6, 2006, 7 pgs.
Unknown, "Entropy and Source Coding (Compression)", TCOM 570, 1999-9, pp. 1-22.
Venkatramani et al., "Securing Media for Adaptive Streaming", Multimedia 2003 Proceedings of the Eleventh ACM International Conference on Multimedia, Nov. 2-8, 2003, Berkeley, California, 4 pgs.
Wang et al., "Image Quality Assessment: From Error Visibility to Structural Similarity", IEEE Transactions on Image Processing, Apr. 2004, vol. 13, No. 4, pp. 600-612.
Wu, Feng et al., "Next Generation Mobile Multimedia Communications: Media Codec and Media Transport Perspectives", In China Communications, Oct. 2006, pp. 30-44.
Zambelli, "IIS Smooth Streaming Technical Overview", Microsoft Corporation, Mar. 2009.
"IBM Closes Cryptolopes Unit," Dec. 17, 1997, CNET News, Printed on Apr. 25, 2014 from http://news.cnet.com/IBM-closes-Cryptolopes-unit/2100-1001_3206465.html, 3 pages.
"Information Technology-Coding of Audio Visual Objects—Part 2: Visual" International Standard, ISO/IEC 14496-2, Third Edition, Jun. 1, 2004, pp. 1-724. (presented in three parts).
U.S. Appl. No. 13/905,804, "Notice of Allowance," dated Aug. 12, 2015, 8 pgs.
Broadq—The Ultimate Home Entertainment Software, printed May 11, 2009 from ittp://web.srchive.org/web/20030401122010/www.broadq.com/qcasttuner/, 1 pg.
Cloakware Corporation, "Protecting Digital Content Using Cloakware Code Transformation Technology", Version 1.2, May 2002, pp. 1-10.
EP11774529 Supplementary European Search Report, completed Jan. 31, 2014, 2 pgs.

European Search Report Application No. EP 08870152, Search Completed May 19, 2011, dated May 26, 2011, 9 pgs.
European Search Report for Application 11855103.5, search completed Jun. 26, 2014, 9 pgs.
European Search Report for Application 11855237.1, search completed Jun. 12, 2014, 9 pgs.
European Supplementary Search Report for Application EP09759600, completed Jan. 25, 2011, 11 pgs.
Extended European Search Report for European Application EP10821672, completed Jan 30, 2014, 3 pgs.
Extended European Search Report for European Application EP11824682, completed Feb 6, 2014, 4 pgs.
Extended European Search Report for European Application No. 14763140.2, Search completed Sep. 26, 2016, dated Oct. 5, 2016, 9 pgs.
Federal Computer Week, "Tool Speeds Info to Vehicles", Jul. 25, 1999, 5 pages.
Final draft ETSI ES 202 109, V1.1.1, ETSI Standard, Terrestrial Trunked Radio (TETRA); Security; Synchronization mechanism for end-to-end encryption, Oct. 2002, 17 pgs.
HTTP Live Streaming Overview, Networking & Internet, Apple, Inc., Apr. 1, 2011, 38 pages.
IBM Corporation and Microsoft Corporation, "Multimedia Programming Interface and Data Specifications 1.0", Aug. 1991, printed from http://www.kk.iij4u.or.jp/~kondo/wave/mpidata.txt on Mar. 6, 2006, 100 pgs.
InformationWeek, "Internet on Wheels", InformationWeek: Front End: Daily Dose, Jul. 20, 1999, Printed on Mar. 26, 2014, 3 pgs.
International Preliminary Report for Application No. PCT/US2011/066927, Filed Dec. 22, 2011, dated Jul. 10, 2013, 13 pgs.
International Preliminary Report for International Application No. PCT/US2011/067243, International Filing Date Dec. 23, 2011, dated Jul. 10, 2013, 7 pgs.
International Preliminary Report on Patentability for International Application PCT/US14/30747, dated Sep. 15, 2015, dated Sep. 24, 2015, 6 pgs.
International Preliminary Report on Patentability for International Application No. PCT/US2007/063950, Report Completed Dec. 18, 2009, 3 pgs.
International Preliminary Report on Patentability for International Application No. PCT/US2008/083816, dated May 18, 2010, 6 pgs.
Bloom et al., "Copy Protection for DVD Video", Proceedings of the IEEE, vol. 87, No. 7, Jul. 1999, pp. 1267-1276.
Bross et al., "High Efficiency Video Coding (HEVC) text specification draft 10 (for FDIS & Last Call)", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, Document: JCTVC-L1003_v34, 12th Meeting: Geneva, CH, Jan. 14-23, 2013 (presented in three parts).
Casares et al., "Simplifying Video Editing Using Metadata", DIS2002, 2002, pp. 157-166.
Concolato et al., "Live HTTP Streaming of Video and Subtitles within a Browser", MMSys 2013, Feb. 26-Mar. 1, 2013, Oslo, Norway, 5 pgs.
Deutscher, "IIS Transform Manager Beta—Using the MP4 to Smooth Task", Retrieved from: https://web.archive.org/web/20130328111303/http://blog.johndeutscher.com/category/smooth-streaming, Blog post of Apr. 29, 2011, 14 pgs.
Eskicioglu et al., "An Integrated Approach to Encrypting Scalable Video", Proceedings IEEE International Conference on Multimedia and Expo, Aug. 26-29, 2002, Lausanne, Switzerland, 4 pgs.
Fecheyr-Lippens, "A Review of HTTP Live Streaming", Internet Citation, Jan. 25, 2010, pp. 1-37.
Gannes, "The Lowdown on Apple's HTTP Adaptive Bitrate Streaming", GigaOM, Jun. 10, 2009, 12 pgs.
Garg et al., "An Experimental Study of Throughput for UDP and VoIP Traffic in IEEE 802.11b Networks", Wireless Communications and Networkings, Mar. 2003, pp. 1748-1753.
Gast, "When is 54 Not Equal to 54? A Look at 802.11a, b and g Throughput", Aug. 8, 2003, printed Oct. 30, 2008 from www.oreillynet.com/pub/a/wireless/2003/08/08/wireless_throughput.html, 4 pgs.

US 10,484,749 B2

Page 10

(56)   **References Cited**

OTHER PUBLICATIONS

Ghosh, "Enhancing Silverlight Video Experiences with Contextual Data", Retrieved from: http://msdn.microsoft.com/en-us/magazine/ee336025.aspx, 2010, 15 pgs.

Griffith, Eric, "The Wireless Digital Picture Frame Arrives", Wi-Fi Planet, printed May 4, 2007 from http://www.wi-fiplanet.com/news/article.php/3093141, Oct. 16, 2003, 3 pgs.

Hartung et al., "DRM Protected Dynamic Adaptive HTTP Streaming", MMSys 2011 Proceedings of the Second Annual ACM Conference on Multimedia Systems, San Jose, California, Feb. 23-25, 2011, pp. 277-282.

Hurtado Guzman, Juan Esteban, "Development and Implementation of an Adaptive HTTP Streaming Framework for H264/MVC Coded Media", Politecnico di Torino, Nov. 2010, 108 pgs.

Hwang et al., "Efficient and User Friendly Inter-domain Device Authentication/Access control for Home Networks", Proceedings of the 2006 International Conference on Embedded and Ubiquitous Computing, Seoul, Korea, Aug. 1-4, 2006, pp. 131-140.

Inlet Technologies, "Adaptive Delivery to iDevices", 2010, 2 pages.

Inlet Technologies, "Adaptive delivery to iPhone 3.0", 2009, 2 pgs.

Inlet Technologies, "HTTP versus RTMP", 2009, 3 pages.

Inlet Technologies, "The World's First Live Smooth Streaming Event: The French Open", 2009, 2 pages.

Kaspar et al., "Using HTTP Pipelining to Improve Progressive Download over Multiple Heterogeneous Interfaces", IEEE ICC proceedings, 2010, 5 pgs.

Kim, Kyuheon, "MPEG-2 ES/PES/TS/PSI", Kyung-Hee University, Oct. 4, 2010, 66 pages.

Kozintsev et al., "Improving last-hop multicast streaming video over 802.11", Workshop on Broadband Wireless Multimedia, Oct. 2004, pp. 1-10.

Kurzke et al., "Get Your Content Onto Google TV", Google, Retrieved from: http://commondatastorage.googleapis.com/io2012/presentations/live%20to%20website/1300.pdf, 2012, 58 pgs.

Lang, "Expression Encoder, Best Practices for live smooth streaming broadcasting", Microsoft Corporation, 2010, retrieved from http://www.streamingmedia.com/conferences/west2010/presentations/SMWest-12010-Expression-Encoder.pdf, 20 pgs.

Levkov, "Mobile Encoding Guidelines for Android Powered Devices", Adobe Systems Inc., Addendum B, Dec. 22, 2010, 42 pgs.

Li et al., "Content-Aware Playout and Packet Scheduling for Video Streaming Over Wireless Links", IEEE Transactions on Multimedia, vol. 10, No. 5, Aug. 2008, pp. 885-895.

Lian et al., "Efficient video encryption scheme based on advanced video coding", Multimed. Tools Appl. vol. 38, 2008, pp. 75-89.

Liu et al., "A Formal Framework for Component Deployment", OOPSLA 2006, Proceedings of the 21st Annual ACM SIGPLAN Conference on Object-Oriented Programming Systems, Language, and Applications, Portland, Oregon, Oct. 22-26, 2006, pp. 325-344.

Long et al., "Silver: Simplifying Video Editing with Metadata", CHI 2003: New Horizons, Apr. 5-10, 2003, pp. 628-629.

Matroska, "Diagram", Matroska, Technical/Info, Diagram, 2016, retrieved from https://www.matroska.org/technical/diagram/index.html on Jul. 20, 2017, 9 pages.

Matroska, "Specifications", Matroska, Technical/Info, Specifications, Jun. 25, 2017, retrieved from https://www.matroska.org/technical/specs/index.html on Jul. 20, 2017, 20 pages.

Miras, "On Quality Aware Adaptation of Internet Video", University of London, PhD dissertation, 2004, 181 pgs.

Morrison, "EA IFF 85 Standard for Interchange Format Files", Jan. 14, 1985, printed from http://www.dcs.ed.ac.uk/home/mxr/gfx/2d/IFF.txt on Mar. 6, 2006, 24 pgs.

Moscoso, Pedro Gomes, "Interactive Internet TV Architecture Based on Scalable Video Coding", Instituto Superior Techico, Universidad Technica de Lisboa, May 2011, 103 pgs.

MSDN, "Adaptive streaming, Expression Studio 2.0", Apr. 23, 2009, 2 pgs.

Nelson, "Arithmetic Coding + Statistical Modeling = Data Compression: Part 1 Arithmetic Coding", Doctor Dobb's Journal, Feb. 1991, USA, pp. 1-12.

Nelson, "Smooth Streaming Deployment Guide", Microsoft Expression Encoder, Aug. 2010, 66 pgs.

Nelson, Michael, "IBM's Cryptolopes", Complex Objects in Digital Libraries Course, Spring 2001, Retrieved from http://www.cs.odu.edu/~mln/teaching/unc/inls210/?method=display&pkg_name=cryptolopes.pkg&element_name=cryptolopes.ppt, 12 pages.

Noboru, "Play Fast and Fine Video on Web! codec", Co.9 No. 12, Dec. 1, 2003, pp. 178-179.

Noe, A., "Matroska File Format (under construction!)", Retrieved from the Internet: URL:http://web.archive.orgweb/20070821155146/www.matroska.org/technical/specs/matroska.pdf [retrieved on Jan. 19, 2011], Jun. 24, 2007, 1-51 pgs.

Noe, Alexander, "AVI File Format", http://www.alexander-noe.com/video/documentation/avi.pdf, Dec. 14, 2006, pp. 1-26.

Noe, Alexander, "Definitions", Apr. 11, 2006, retrieved from http://www.alexander-noe.com/video/amg/definitions.html on Oct. 16, 2013, 2 pages.

Ooyala, "Widevine Content Protection", Ooyala Support Center for Developers. Ooyala, Inc., 2013. Jun. 3, 2013. http://support.ooyala.com/developers/documentation/concepts/player_v3_widevine_integration.html.

Oyman et al., "Quality of Experience for HTTP Adaptive Streaming Services", IEEE Communications Magazine, Apr. 2012, vol. 50, No. 4, pp. 20-27, DOI: 10.1109/MCOM.2012.6178830.

Ozer, "The 2012 Encoding and Transcoding Buyers' Guide", Streamingmedia.com, Retrieved from: http://www.streamingmedia.com/Articles/Editorial/Featured-Articles/The-2012-Encoding-and-Transcoding-Buyers-Guide-84210.aspx, 2012, 8 pgs.

Ozer, Jan, "Adaptive Streaming in the Field", Streaming Media, Dec. 2010-Jan. 2011, pp. 36-47.

Padiadpu, Rashmi, "Towards Mobile Learning: A SCORM Player for the Google Android Platform", Master Thesis, Hamburg University of Applied Sciences, 2008, 66 pgs.

Pantos, "HTTP Live Streaming, draft-pantos-http-live-streaming-10", IETF Tools, Oct. 15, 2012, Retrieved from: http://tools.ietf.org/html/draft-pantos-http-live-streaming-10, 37 pgs.

Pantos, R, "HTTP Live Streaming: draft-pantos-http-live-streaming-06", Published by the Internet Engineering Task Force (IETF), Mar. 31, 2011, 24 pages.

Papagiannaki et al., "Experimental Characterization of Home Wireless Networks and Design Implications", INFOCOM 2006, 25th IEEE International Conference of Computer Communications, Proceedings, Apr. 2006, 13 pgs.

Peek, David, "Consumer Distributed File Systems", Dissertation, Doctor of Philosophy, Computer Science and Engineering, The University of Michigan, 2009, 118 pgs.

Phamdo, "Theory of Data Compression", printed on Oct. 10, 2003, 12 pgs.

"IBM Spearheading Intellectual Property Protection Technology for Information on the Internet; Cryptolope Containers Have Arrived", May 1, 1996, Business Wire, Printed on Aug. 1, 2014 from http://www.thefreelibrary.com/IBM+Spearheading+Intellectual+Property+Protection+Technology+for...-a018239381, 6 pgs.

"Information Technology—Coding of audio-visual objects—Part 14: MP4 file format", International Standard, ISO/IEC 14496-14, First Edition, Nov. 15, 2003, 18 pages.

"Information Technology—Coding of audio-visual objects—Part 17: Streaming text", International Organisation for Standardisation, Feb. 2004, 22 pages.

"Information technology—Coding of audio-visual objects—Part 18: Font compression and streaming", ISO/IEC 14496-18, First edition Jul. 1, 2004, 26 pages.

"Information technology—Generic coding of moving pictures and associated audio information: Systems", International Standard ISO/IEC 13818-1, Second Edition, Dec. 1, 2000, 174 pages (presented in two parts).

"Information-Technology—Generic coding of moving pictures and associated audio: Systems, Recommendation H.222.0", International Standard, ISO/IEC 13818-1, Draft 1209, Apr. 25, 1995, 151 pages.

US 10,484,749 B2

Page 11

(56)   **References Cited**

OTHER PUBLICATIONS

"Information-Technology—Generic coding of moving pictures and associated audio: Systems, Recommendation H.222.0", International Standard, ISO/IEC 13818-1, Draft 1540, Nov. 13, 1994, 161 pages.

"Innovation of technology arrived", I-O Data, Nov. 2004, Retrieved from http://www.iodata.com/catalogs/AVLP2DVDLA_Flyer200505.pdf on May 30, 2013, 2 pgs., I-O Data, 2 pgs.

"KISS Players, KISS DP-500", retrieved from http://www.kiss-technology.com/?p=dp500 on May 4, 2007, 1 pg.

"Matroska", Wikipedia, Jul. 10, 2017, retrieved from https://en.wikipedia.org/wiki/Matroska on Jul. 20, 2017, 3 pages.

"Matroska Streaming | Matroska", Retrieved from the Internet: URL:http://web.archive.org/web/201 0121711431 O/http://matroska.org/technical!streaming/index.html [retrieved on Jan. 29, 2016], Dec. 17, 2010.

"MovieLabs Specification for Next Generation Video—Version 1.0", Motion Picture Laboratories, Inc., 2013, Retrieved from: http://movielabs.com/ngvideo/MovieLabs%20Specification%20for%20Next%20Generation%20Video%20v1.0.pdf, 5 pgs.

"MPEG-2", Wikipedia, Jun. 13, 2017, retrieved from https://en.wikipedia.org/wiki/MPEG-2 on Jul. 20, 2017, 13 pages.

"MPEG-4 File Format, Version 2", Sustainability of Digital Formats: Planning for Library of Congress Collections, Retrieved from: https://www.loc.gov/preservation/digital/formats/fdd/fdd000155.shtml, Last updated Feb. 21, 2017, 8 pgs.

"MPEG-4 Part 14", Wikipedia, Jul. 10, 2017, retrieved from https://en.wikipedia.org/wiki/MPEG-4_Part_14 on Jul. 20, 2017, 5 pages.

"Netflix turns on subtitles for PC, Mac streaming", Yahoo! News, Apr. 21, 2010, Printed on Mar. 26, 2014, 3 pgs.

"OpenDML AVI File Format Extensions", OpenDML AVI M-JPEG File Format Subcommittee, retrieved from www.the-labs.com/Video/odmlff2-avidef.pdf, Sep. 1997, 42 pgs.

"OpenDML AVI File Format Extensions Version 1.02", OpenDML AVI MJPEG File Format Subcommittee. Last revision: Feb. 28, 1996. Reformatting: Sep. 1997.

"QCast Tuner for PS2", printed May 11, 2009 from http://web.archive.org/web/20030210120605/www.divx.com/software/detail.php?ie=39, 2 pgs.

"Series H: Audiovisual and Multimedia Systems Infrastructure of audiovisual services—Coding of moving video; High efficiency video coding", International Telecommunication Union, ITU-T H.265, Apr. 2015, 634 pages (presented in six parts).

"Smooth Streaming Client", The Official Microsoft IIS Site, Sep. 24, 2010, 4 pages.

"Specifications | Matroska", Retrieved from the Internet: URL:http://web.archive.org/web/201 00706041303/http:/1www.matroska.org/technical/specs/index.html Retrieved on Jan. 29, 2016, Jul. 6, 2010.

"Specifications Matroska", Dec. 17, 2010, [retrieved on Mar. 2, 2018], 12 pages.

"Supplementary European Search Report for Application No. EP 10834935, International Filing Date Nov. 15, 2010, Search Completed May 27, 2014, 9 pgs."

"Supported Media Formats", Supported Media Formats, Android Developers, Printed on Nov. 27, 2013 from developer.android.com/guide/appendix/media-formats.html, 3 pgs.

"Text of ISO/IEC 14496-18/COR1, Font compression and streaming", ITU Study Group 16—Video Coding Experts Group—ISO/IEC MPEG & ITU-T VCEG(ISO/IEC JTC1/SC29/WG11 and ITU-T SG16 06), No. N8664, Oct. 27, 2006, 8 pgs.

"Text of ISO/IEC 14496-18/FDIS, Coding of Moving Pictures and Audio", ITU Study Group 16—Videocoding Experts Group—ISO/IEC MPEG & ITU-T VCEG(ISO/IEC JTC1/SC29/WG11 and ITU-T SG16 06), No. N6215, Dec. 2003, 26 pgs.

"Thread: SSME (Smooth Streaming Medial Element) config.xml review (Smooth Streaming Client configuration file)", Printed on Mar. 26, 2014, 3 pgs.

"Transcoding Best Practices", From movideo, Printed on Nov. 27, 2013 from code.movideo.com/Transcoding_Best_Practices, 5 pgs.

"Using HTTP Live Streaming", iOS Developer Library, http://developer.apple.com/library/ios/#documentation/networkinginternet/conceptual/streamingmediaguide/UsingHTTPLiveStreaming/UsingHTTPLiveStreaming.html#//apple_ref/doc/uid/TP40008332-CH102-SW1, Feb. 11, 2014, 10 pgs.

"Video Manager and Video Title Set IFO file headers", printed Aug. 22, 2009 from http://dvd.sourceforge.net/dvdinfo/ifo.htm, 6 pgs.

"What is a DVD?", printed Aug. 22, 2009 from http://www.videohelp.com/dvd, 8 pgs.

"What is a VOB file", http://www.mpucoder.com/DVD/vobov.html, printed on Jul. 2, 2009, 2 pgs.

"What's on a DVD?", printed Aug. 22, 2009 from http://www.doom9.org/dvd-structure.htm, 5 pgs.

U.S. Appl. No. 13/224,298, "Final Office Action Received", dated May 19, 2014, 26 pgs.

U.S. Appl. No. 13/905,804, "Non-Final Office Action Received", dated Jul. 25, 2014, 15 pgs.

Adams et al., "Will http adaptive streaming become the dominant mode of video delivery in cable networks?", https://www.nctatechnicalpapers.com/Paper/2011/2011-will-http-adaptive-streaming-become-the-dominant-mode-of-video-delivery-in-cable-networks-, 10 pgs.

Adhikari et al., "Unreeling Netflix: Understanding and Improving Multi-CDN Movie Delivery", 2012 Proceedings IEEE InfoCom, Mar. 25-30, 2012, Orlando, Florida, 9 pgs.

Adzic et al., "Optimized Adaptive HTTP Streaming for Mobile Devices", International Society for Optics and Photonics, Applications of Digital Image Processing XXXIV, vol. 8135, Sep. 2011, p. 81350T.

Akhshabi et al., "An Experimental Evaluation of Rate-Adaptation Algorithms in Adaptive Streaming over HTTP", MMSys'11, Feb. 23-25, 2011, 12 pgs.

Anonymous, "Method for the encoding of a compressed video sequence derived from the same video sequence compressed at a different bit rate without loss of data", ip.com, ip.com No. IPCOM000008165D, May 22, 2002, pp. 1-9.

Author Unknown, "Blu-ray Disc—Blu-ray Disc—Wikipedia, the free encyclopedia", printed Oct. 30, 2008 from http://en.wikipedia.org/wiki/Blu-ray_Disc, 11 pgs.

Author Unknown, "Blu-ray Movie Bitrates Here—Blu-ray Forum", printed Oct. 30, 2008 from http://forum.blu-ray.com/showthread.php?t=3338, 6 pgs.

Author Unknown, "MPEG-4 Video Encoder: Based on International Standard ISO/IEC 14496-2", Patni Computer Systems, Ltd., printed Jan 24, 2007, USA, pp. 1-15.

Author Unknown, "O'Reilly—802.11 Wireless Networks: The Definitive Guide, Second Edition", printed Oct. 30, 2008 from http://oreilly.com/catalog/9780596100520, 2 pgs.

Author Unknown, "Tunneling QuickTime RTSP and RTP over HTTP", Published by Apple Computer, Inc.: 1999 (month unknown), 6 pages.

Author Unknown, "Turbo-Charge Your Internet and PC Performance", printed Oct. 30, 2008 from Speedtest.net—The Global Broadband Speed Test, 1 pg.

Author Unknown, "White paper, The New Mainstream Wireless LAN Standard", Broadcom Corporation, Jul. 2003, 12 pgs.

Blasiak, "Video Transrating and Transcoding: Overview of Video Transrating and Transcoding Technologies", Ingenient Technologies, TI Developer Conference, Aug. 6-8, 2002, 22 pgs.

International Preliminary report on Patentability for International Application No. PCT/US2005/025845, dated Jun. 19, 2007, 1 page.

Written Opinion for International Application No. PCT/US2007/063950 filed Mar. 14, 2007, report completed Mar. 1, 2008; dated Mar. 19, 2008, 6 pgs.

Bocharov et al., "Portable encoding of audio-video objects: The Protected Interoperable File Format (PIFF)", Microsoft Corporation, Sep. 8, 2009, Revised: Mar. 9, 2010, 32 pgs.

"Microsoft Announces Breakthrough Technology Enabling Simple Access to Broad Set of Digital Content, Including Music, Games, Video, Ring Tones and Pictures", Microsoft, Feb. 12, 2017, Retrieved from https://news.microsoft.com/2007/02/12/microsoft-announces-

US 10,484,749 B2

Page 12

(56)   **References Cited**

OTHER PUBLICATIONS

breakthrough-technology-enabling-simple-access-to-broad-set-of-
digital-content-including-music-games-video-ring-tones-and-
pictures/, 5 pgs.

* cited by examiner
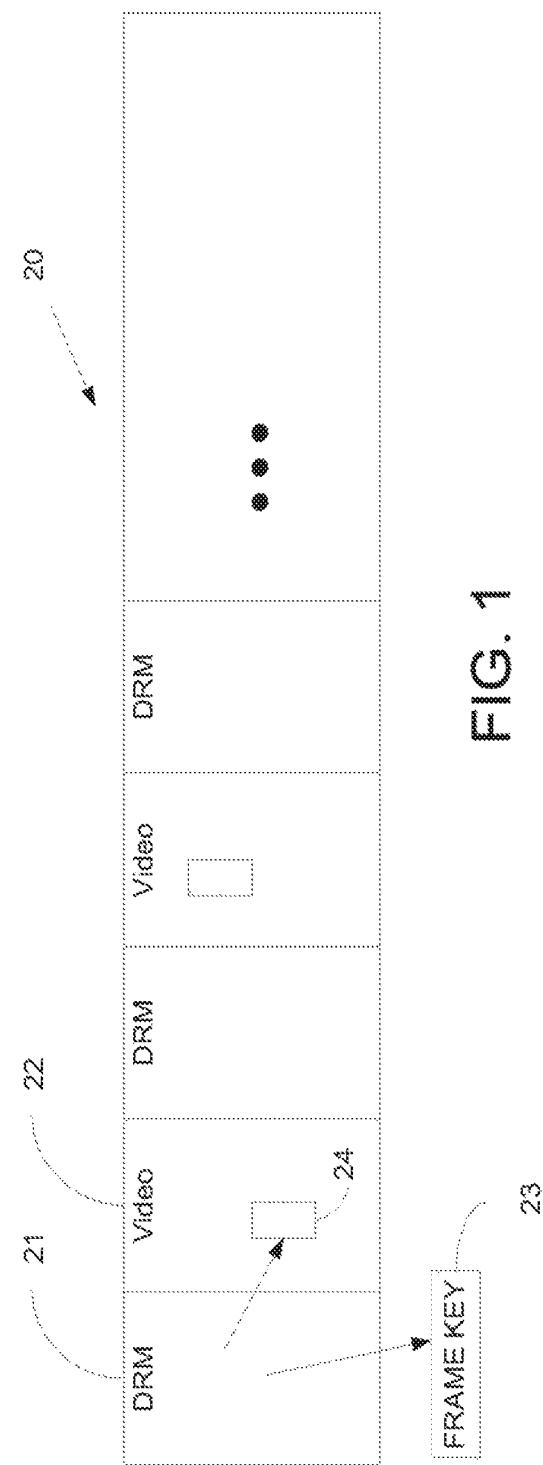
FIG. 1

FIG. 2

FIG. 3

FIG. 4

Receive the encrypted transmitted data
201

Decipher the received cryptographic information
202

Decrypt the encrypted video data utilizing the retrieved cryptographic information
203

Decode the decrypted video/audio data for playback
204
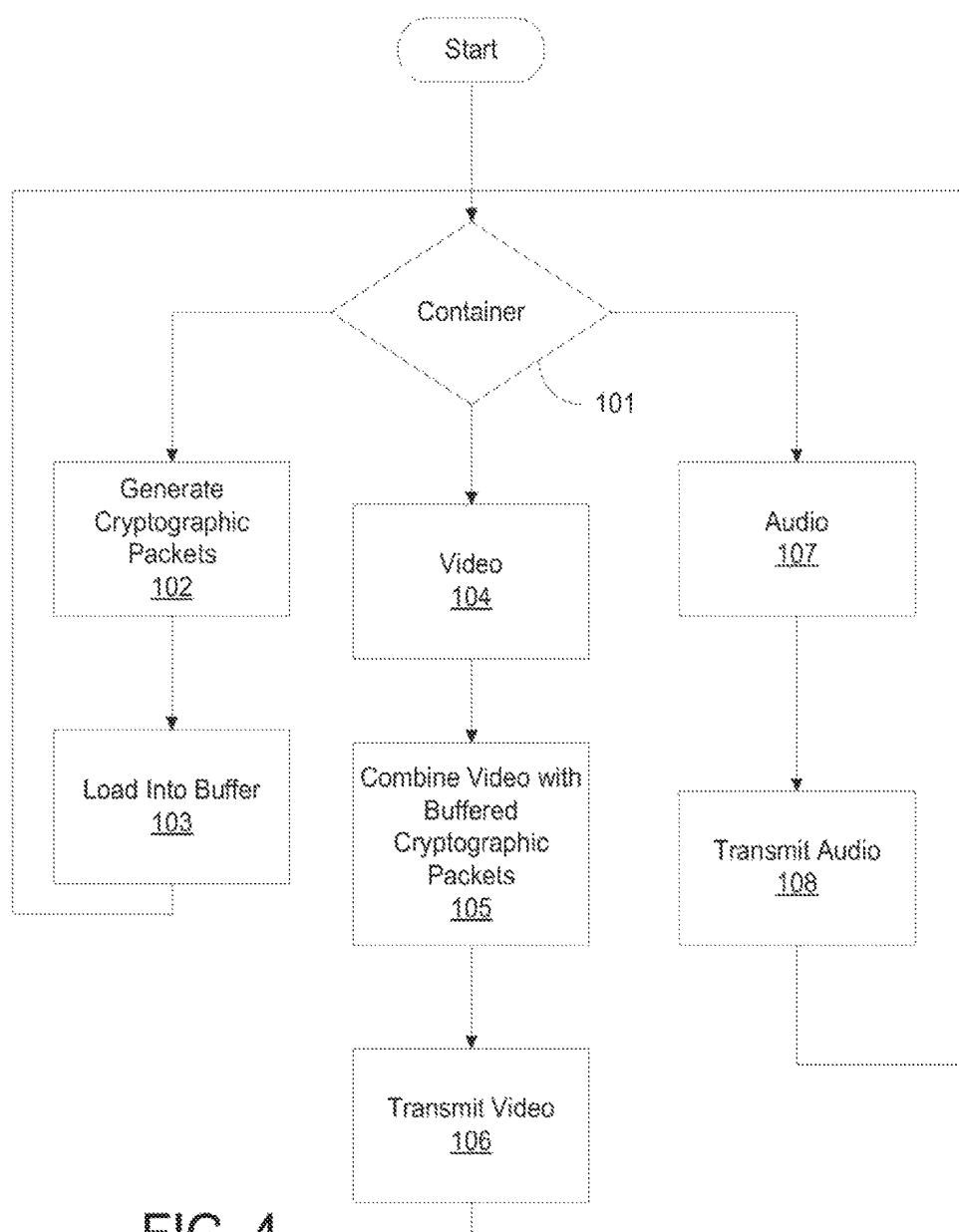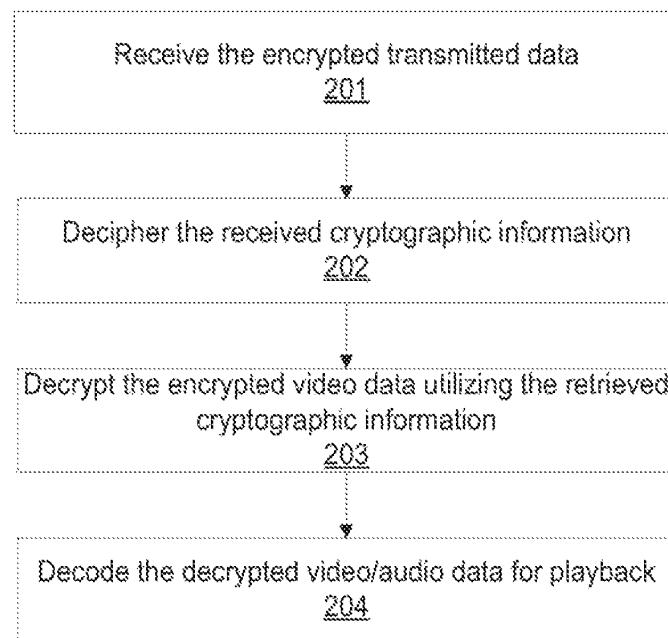
FIG. 5
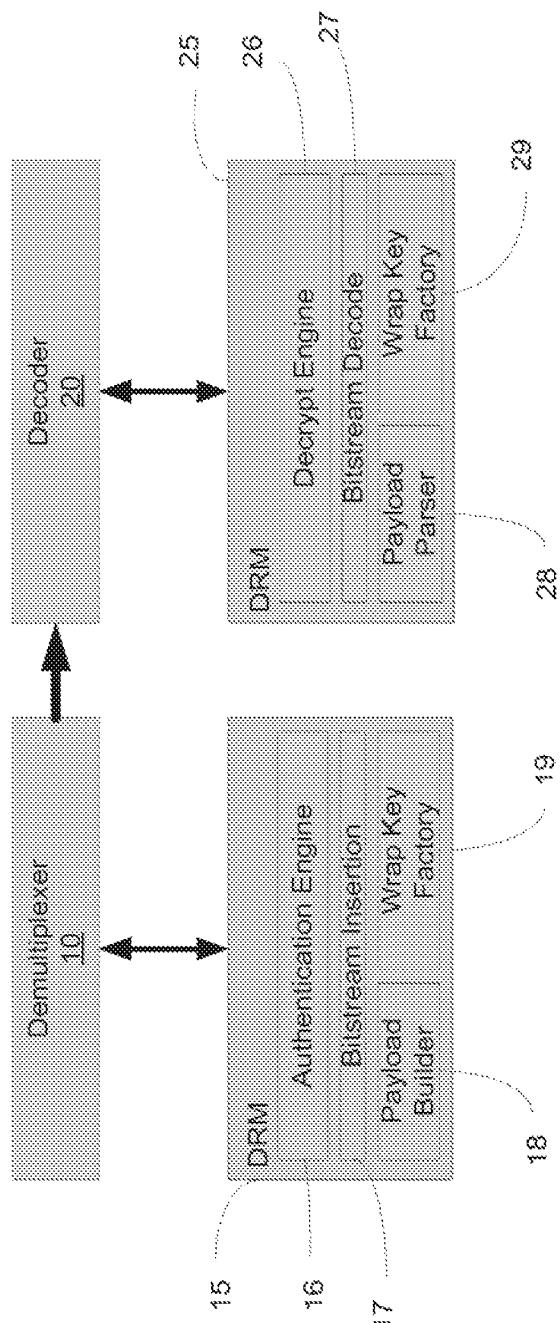
FIG. 6
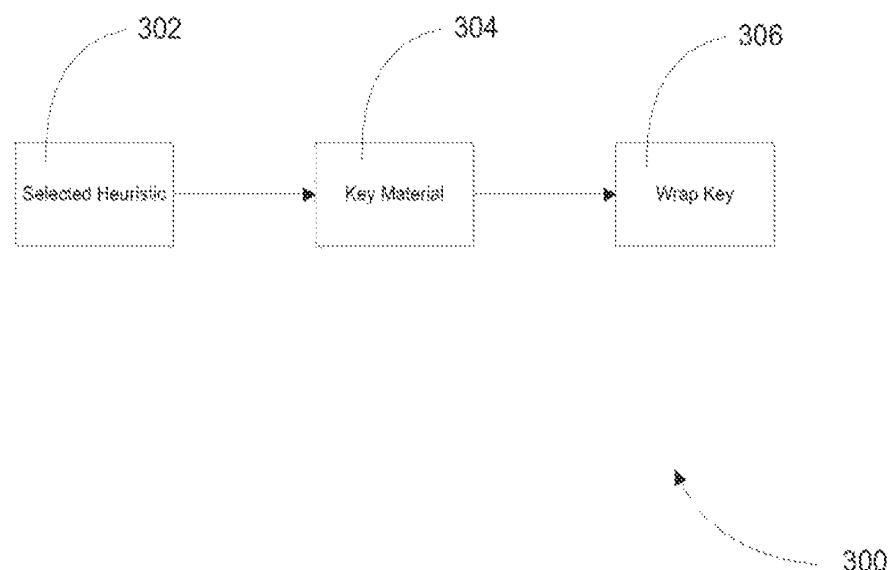
FIG. 7
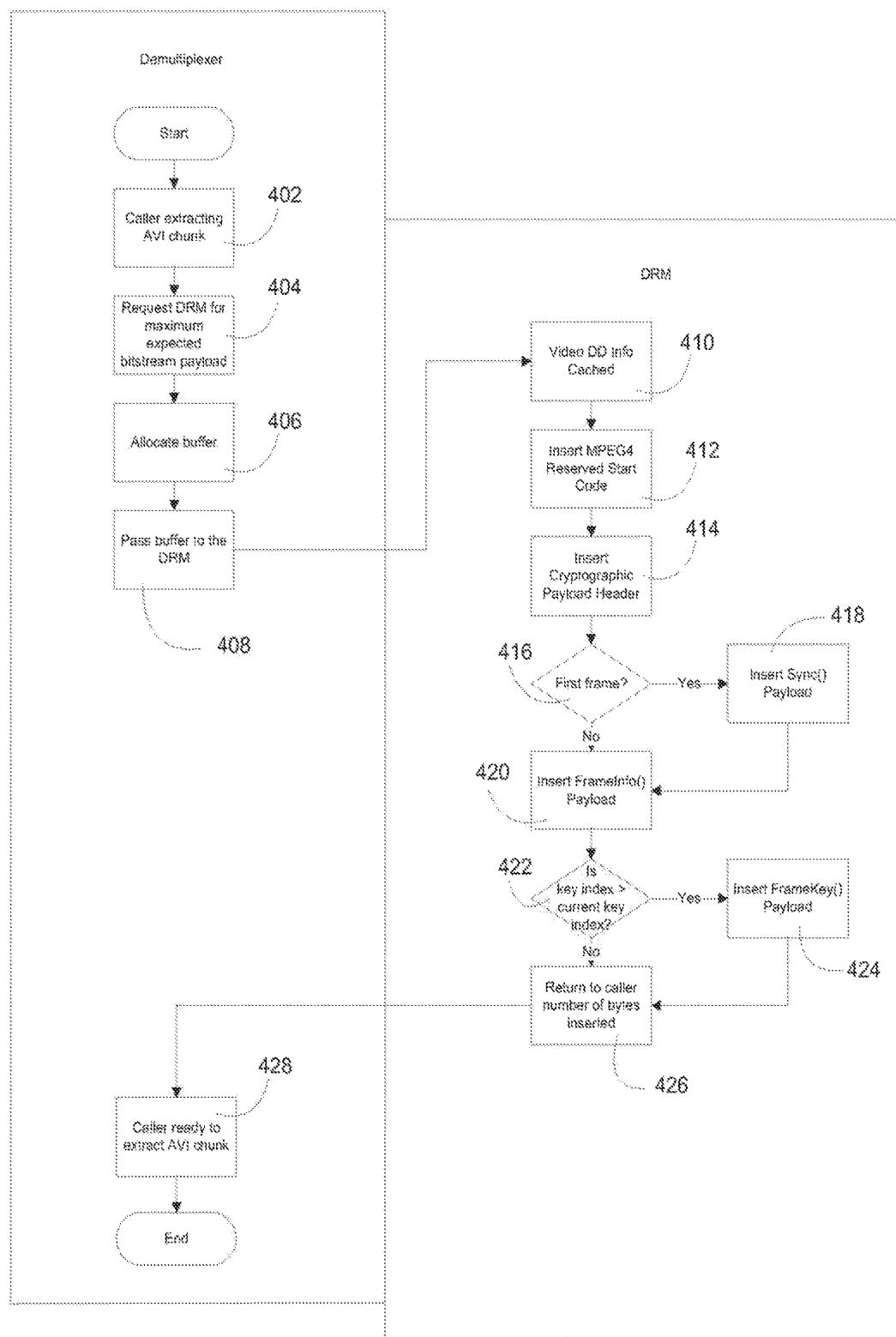
FIG. 8

US 10,484,749 B2

1

SYSTEMS AND METHODS FOR SECURE PLAYBACK OF ENCRYPTED ELEMENTARY BITSTREAMS

CROSS-REFERENCE TO RELATED APPLICATIONS

The current application is a continuation application of U.S. application Ser. No. 15/615,626 filed Jun. 6, 2017 entitled "Elementary Bitstream Cryptographic Material Transport Systems and Methods" which application is a continuation of U.S. application Ser. No. 14/839,783 filed Aug. 28, 2015 entitled "Elementary Bitstream Cryptographic Material Transport Systems and Methods" which application is a continuation of U.S. application Ser. No. 14/306,146 filed Jun. 16, 2014, and issued on Sep. 1, 2015 as U.S. Pat. No. 9,124,773, entitled "Elementary Bitstream Cryptographic Material Transport Systems and Methods" which application is a continuation application of U.S. application Ser. No. 12/946,631 filed Nov. 15, 2010, and issued on Jul. 15, 2014 as U.S. Pat. No. 8,781,122, entitled "Elementary Bitstream Cryptographic Material Transport Systems and Methods" which claims priority to U.S. Provisional Patent Application No. 61/266,982, filed Dec. 4, 2009, the disclosures of which are incorporated herein by reference.

BACKGROUND

The present invention generally relates to digital multimedia distribution systems and more specifically to digital transmission of encrypted multimedia content over an unsecured connection.

Providers of multimedia content can digitize content for distribution via digital communication networks. An important issue faced by a content distribution system is enabling only those customers that have purchased the content to play the content and compartmentalize access to all the stakeholders in the content distribution chain. One approach is to encrypt portions of the content and to issue encryption keys to authorized users that enable encrypted portions of the content to be unencrypted. Layers of keys and protection policies can be used so a single encryption key alone is insufficient for the user to access the content. In a number of systems, users purchase players that possess specified decryption capabilities. Content providers can distribute content to user's owning such a player in an encryption format supported by the player. Complying with a specified protection policy typically involves using an encryption key specified by the manufacturer of the players. In many instances the manufacturer of the players will not reveal the encryption keys used in the specified encryption scheme and likewise the content provider does not want to share the content keys to the manufacturer of the players.

Communications between components or processes of players or playback systems are typically trustworthy and secured. However, when communication or the transporting of information becomes unsecured or untrustworthy, such gaps need to be accounted for and filled. This has become more evident with advent and popularity of open multimedia frameworks. Bi-directional communication requirements and/or run time challenges and authentication requests to fill such gaps have proved to be less than adequate.

There are many ways of securing communication, including ciphering and encryption.

Ciphering is a procedure used to secure data that typically involves using a series of steps to scramble and render the

2

data readable only to the intended audience. The procedure itself does not require an outside source, such as a key, in order to encipher or decipher the data. Rather, data can be properly deciphered by the intended audience so long as deciphering exactly follows the enciphering steps to unravel the data. Encryption is a procedure used to secure data. That typically involves the use of an external input for at least one step in the procedure, such as a key, in order to secure and/or access the data. The external data is used to intentionally manipulate at least one step in the encryption or decryption process, changing the way the data processing for encryption occurs. Generally, without the external data or a corresponding decryption key in an encryption process, a step in a corresponding decryption process cannot properly be executed and the data cannot be properly decrypted.

In the context of digital media, encoding is a procedure by which digital media is represented in a digital format. The format is typically selected to obtain specific benefits during the transportation, playback and storage of the digital media format used. For example, representing the media using fewer bits may be beneficial to transfer data in order to minimize bandwidth usage or storage space. In another example, a media player may only decode or read media in a certain format and therefore the digital media may first be in that format in order to be decoded by that media player.

Decoding is a procedure by which digital media in a format is translated into a format readable by a media player for rendering on a display device. Often, decoding may also reverse processes associated with encoding such as compression. In instances where encryption and/or enciphering have been applied to encoded media, the enciphering process or encryption process typically must be reversed before the encoded media can be decoded.

SUMMARY OF THE INVENTION

Systems and methods are described for taking cryptographic material from a container file and inserting the cryptographic material in an elementary bitstream, where the cryptographic information can then be used to decrypt the elementary bitstream for playback

A number of embodiments include obtaining the cryptographic information, extracting the at least partially encrypted video data from the container file to create an elementary bitstream, enciphering the cryptographic information, inserting the cryptographic information in the elementary bitstream, providing the elementary bitstream to a video decoder, extracting the cryptographic information from the elementary bitstream at the video decoder, deciphering the cryptographic information, decrypting the elementary bitstream with the cryptographic information and decoding the elementary bitstream for rendering on a display device using the video decoder.

In a further embodiment, the cryptographic information is obtained from the container file.

In another embodiment, the cryptographic information includes key information and information concerning at least a portion of the at least partially encrypted video data that is encrypted using the key information.

In an additional embodiment, information concerning at least a portion of the at least partially encrypted video data is a reference to a block of encrypted data within an encoded frame of video that is encrypted using the key information.

In a still further embodiment, the cryptographic information inserted in the elementary bitstream is delimited by an

US 10,484,749 B2

3   4

identifier and the cryptographic information is inserted before the at least partially encrypted video data encrypted using the key information.

In a still other embodiment, the cryptographic information is extracted using the identifier.

In a still additional embodiment, the decrypting process is performed by using the key information to identify the encrypted portion of video data and decrypting the encrypted video data using the key information.

In a yet further embodiment, cryptographic information inserted in different locations within the elementary bitstream includes different key information.

In a yet other embodiment, the at least partially encrypted video data includes frames of encoded video. In addition, the at least partially encrypted video data includes at least a portion of a plurality of the encoded frames that is encrypted.

In a yet further additional embodiment, the enciphering process and the deciphering process are synchronized such that a delay in excess of a predetermined time between enciphering and deciphering results in the cryptographic information being unrecoverable.

In a still further embodiment again, the enciphering process enciphers data by using a sequence of scrambling processes to scramble data.

In a still other embodiment again, the deciphering process deciphers data by performing the inverse sequence of scrambling processes to the sequence used to scramble the data.

Many embodiments include a demultiplexer configured to extract the at least partially encrypted video data from the container file to create an elementary bitstream, a video decoder configured to decrypt the elementary bitstream using the cryptographic information and decode the elementary bitstream for rendering on a display device. Additionally, the demultiplexer is configured to encipher the cryptographic information and insert the enciphered cryptographic information in the elementary bitstream and the decoder is configured to extract enciphered cryptographic information from an elementary bitstream and to decipher the cryptographic information.

In a further embodiment, the cryptographic information is obtained from the container file.

In another embodiment, the cryptographic information includes key information and information concerning at least a portion of the at least partially encrypted video data that is encrypted using the key information.

In an additional embodiment, the information concerning at least a portion of the at least partially encrypted video data is a reference to a block of encrypted data within an encoded frame of video that is encrypted using the key information.

In a further embodiment again, the demultiplexer is configured to insert the cryptographic information delimited by an identifier in the elementary bitstream and insert the cryptographic information before the at least partially encrypted video data encrypted using the key information.

In another embodiment again, the decoder is configured to extract the cryptographic information using the identifier.

In an additional embodiment again, the decoder is configured to decrypt the portion of the video data encrypted using the key information by identifying the encrypted portion of video data and decrypting the encrypted video data using the key information.

In a still further embodiment again, cryptographic information inserted in different locations within the elementary bitstream includes different key information.

In still another embodiment again, the at least partially encrypted video data includes frames of encoded video. Additionally, at least a portion of a plurality of the encoded frames is encrypted.

In a still additional embodiment, both the demultiplexer and the decoder are configured to be synchronized such that a delay in excess of a predetermined time between enciphering and deciphering results in the cryptographic information being unrecoverable.

In a yet further embodiment, the demultiplexer is configured to encipher data by using a sequence of scrambling processes to scramble data.

In a yet other embodiment, the decoder is configured to decipher data by performing the inverse sequence of scrambling processes to the sequence used to scramble the data.

Numerous embodiments include obtaining the cryptographic information. In addition, the cryptographic information is obtained from the container file. Also, the at least partially encrypted video data includes frames of encoded video and at least a portion of a plurality of the encoded frames is encrypted. Additionally, the cryptographic information includes key information and information concerning at least a portion of the least partially encrypted video data that is encrypted using the key information. Furthermore, the information concerning at least a portion of the at least partially encrypted video data is a reference to a block of encrypted data within an encoded frame of video that is encrypted using the key information and the cryptographic information inserted in different locations within the elementary bitstream includes different key information.

Several embodiments include extracting the at least partially encrypted video data from the container file to create an elementary bitstream. In addition, the cryptographic information inserted in the elementary bitstream is delimited by an identifier and the cryptographic information is inserted before the at least partially encrypted video data encrypted using the key information.

Many embodiments include enciphering the cryptographic information and inserting the cryptographic information in the elementary bitstream. In addition, the cryptographic information is extracted using the identifier.

A number of embodiments include providing the elementary bitstream to a video decoder, extracting the cryptographic information from the elementary bitstream at the video decoder and deciphering the cryptographic information. In addition, the enciphering process and the deciphering process are synchronized such that a delay in excess of a predetermined time between enciphering and deciphering results in the cryptographic information being unrecoverable. Also, the enciphering process enciphers data by using a sequence of scrambling processes to scramble data. Furthermore, the deciphering process deciphers data by performing the inverse sequence of scrambling processes in the sequence used to unscramble data.

Several embodiments include decrypting the elementary bitstream with the cryptographic information. In addition, the decrypting process is performed by using the key information to identify the encrypted portion of video data and decrypting the encrypted video data using the key information.

Many embodiments include decoding the elementary bitstream for rendering on a display device using the video decoder.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a graphical representation of a multimedia container file in accordance with various embodiments of the present invention.

US 10,484,749 B2

5   6

FIG. **2** illustrates a graphical representation of a bitstream with cryptographic material in accordance with various embodiments of the present invention.

FIG. **3** is a block diagram of a multimedia cryptographic bitstream transport system in accordance with various embodiments of the present invention.

FIG. **4** is a flow diagram of a demultiplex and authentication process in accordance with various embodiments of the present invention.

FIG. **5** is a flow diagram of a decoder and decipher process in accordance with various embodiments of the present invention.

FIG. **6** is a block diagram of a multimedia cryptographic bitstream transport system in accordance with various embodiments of the present invention.

FIG. **7** is a flow diagram of a wrap key generation process in accordance with various embodiments of the present invention.

FIG. **8** is a flow diagram of a bitstream insertion process in accordance with various embodiments of the present invention.

DETAILED DESCRIPTION

Systems and methods for providing multimedia content from one process or component to another process or component over an unsecured connection are provided. In several embodiments, the transmission occurs between a demultiplexer and a decoder over an unsecured connection where traditionally such connections are secured. In many embodiments, the transmission occurs on a bi-directional communication path. Embodiments of the present invention do not secure the transmission but rather secure the data being transmitted via the unsecured connection. The transmitted data in a number of embodiments includes an encrypted multimedia bitstream and associated cryptographic material in the bitstream for transmission to a decoder for decryption. In various embodiments, a bi-directional communication path between a demultiplexer and the decoder is not used. Additionally, by allowing the decryption to occur on the decoder the bitstream is protected even if the connection is compromised and an unauthorized component or process intercepts the bitstream.

In various embodiments, frame keys are used to decrypt the bitstream. For example, in the manner described in U.S. Pat. No. 7,295,673 to Grab et al. the disclosure of which is incorporated by reference herein in its entirety. In several embodiments, the frame keys are protected by a cryptographic wrap algorithm that uses a separate series of newly generated keys. The wrapped frame keys are inserted into the encrypted bit stream for deciphering and decoding by the decoder. The cryptographic information in various embodiments includes information to decrypt a video frame or a portion of the video frame. In various embodiments, a time indicator in the form of a frame sequence is also utilized to ensure connection between the demultiplexer and decoder is not being intercepted or spied upon.

The cryptographic information inserted into the elementary bitstream can take any of a variety of forms. In many embodiments, the cryptographic information includes a frame key and/or a reference to a block of encrypted video data. In several embodiments, the cryptographic information contains an index to a frame key or a separate reference to both a frame key and an encrypted block. A number of embodiments provide for first inserting a table of possible keys and still further embodiments provide for sending multiple keys where different keys are used to encrypt different portions of the video.

Turning now to the drawings, FIG. **1** represents a multimedia container file **20** including encrypted content, e.g., video. The multimedia container file includes a digital rights management portion **21** preceding associated video portions or chunks **22**. The digital rights management portion includes at least one frame key **23** or an index to a frame key in a separately provided table of frame keys, which in many embodiments is encrypted in a way that only enables playback by a particular device and/or user. The digital rights management portion also points to or identifies a specified portion of or an entire video frame within the video chunk **24** that is encrypted. Without first decrypting this encrypted portion of the video chunk, the video content cannot be decoded or displayed. The multimedia container file is supplied to a demultiplexer.

The demultiplexer parses the multimedia container file and transmits portions or chunks of data, e.g., video or audio, to a decoder. However, prior to transmitting the video data, the demultiplexer incorporates or attaches cryptographic material to the video data.

FIG. **2** graphically illustrates the generated multimedia bitstream sent to the decoder. The bitstream **30** includes a header or user data **31** that includes cryptographic material **32**. In accordance with many embodiments of the invention, the material includes the frame key **23** from the multimedia container file, which is encrypted using a wrap key, and wrap key information **34** to provide synchronization of the demultiplexer to the decoder in order to decipher the cryptographic material. As is discussed below, the wrap key information can take any of a variety of different forms depending upon the specific application including but not limited to information enabling synchronization of wrap key factories and/or the direct transfer of the wrap keys themselves. The associated video data **33** follows.

Referring now to FIG. **3**, a demultiplexer **10** that receives a multimedia container file that includes video and audio data, portions of which are encrypted, is shown. In one embodiment, the multimedia file conforms to a specific format such as audio video interleave (AVI) or Matroska (MKV). The multimedia file is provided via a disc, flash memory device or another tangible storage medium or streamed or otherwise transmitted to the demultiplexer. The demultiplexer separates portions of the received multimedia data including but not limited to video, audio and encryption data that is supplied to an upstream digital rights management component **15**. In various embodiments, the connection between the demultiplexer **10** and the digital rights management component **15** can be secure although need not be depending upon the requirements of the application. The digital rights management component **15** generates cryptographic material and the multimedia bitstream transport that is supplied to a decoder **20**. In particular, the demultiplexer **10** transmits video data with cryptographic material to the decoder **20**.

The connection between the demultiplexer and the decoder is typically secured. However, in the illustrated embodiment, the connection is not secured. Typically, the multimedia file is authorized and decrypted in a demultiplexer and then transmitted downstream unencrypted to the decoder via an inter-communication data channel. This however can present a security problem due to the high value of the unencrypted but still encoded bitstream that can be captured during transmission. This bitstream is considered high-value since the encoded data can be easily multiplexed back into a container for unprotected and unauthor-

7
8

ized views and/or distribution with no loss in the quality of the data. In the illustrated embodiment, the video provided to the decoder **20** by the demultiplexer **10** is at least partially encrypted and the decoder **20** communicates with a downstream digital rights management component **25** that deciphers the cryptographic material. Utilizing the deciphered cryptographic material, the digital rights management component is able to access the encryption data and thereby decrypt and decode the video data for playback.

The general processes of the demultiplexer and the decoder are now described. In FIG. **4**, the demultiplexer and authentication process is illustrated in which a multimedia container file is received and portions of which are identified or separated (**101**). If encryption data is identified, cryptographic packets or material are generated (**102**) and stored in a temporary buffer (**103**). However, if video data is identified (**104**), the cryptographic material stored in the temporary buffer is combined with the video data (**105**) and then transmitted to a video decoder (**106**). If audio data is identified (**107**), the audio data is transmitted (**108**) to the audio decoder. It should be appreciated that audio or other types of data may also include encryption data and thus associated cryptographic material is generated and combined with the associated data and transmitted to the respective decoder. Also, other types of data may be included in the container file without encryption data and thus is transmitted directly to the associated decoder.

In FIG. **5**, a decoder and decipher process is illustrated in which the decoder receives video and/or audio data sent from the demultiplexer (**201**). The decoder deciphers the cryptographic material supplied with the associated data (**202**). Utilizing the deciphered material, the encrypted data is decrypted (**203**) and decoded (**204**) by the decoder for playback.

To further elaborate on the demultiplexer and decoder processes and the bitstream transport system, a more detailed representation of the demultiplexer's and decoder's associated digital rights manager along with the associated processes are illustrated in the remaining figures.

Referring to FIG. **6**, the upstream digital rights manager **15** of the demultiplexer **10** includes an authentication engine **16**, a bit stream inserter **17**, a payload builder **18** and a wrap key factory **19**. The downstream digital rights manager **25** of the decoder includes a decrypt engine **26**, a bit stream decoder **27**, a payload parser **28** and a wrap key factory **29**. The authentication engine prepares cryptographic material utilizing the encryption data from the container file and the video data in conjunction with the payload builder **18** and the wrap key factory **19**.

The payload builder **18** provides discrete units of cryptographic material in the bitstream delimited by an identifier. On the decoder, the payload parser **28** utilizes the identifiers to extract the discrete units, which are then processed by the decrypt engine **26**. In many embodiments, the cryptographic material in one embodiment includes a bitstream frame header along with a cryptographic payload. The cryptographic payload, however, is not dependent on the format of the header of the elementary bitstream, e.g., MPEG-4 or H.264.

In one embodiment, the payload builder **18** inserts a reserved start code identifier along with a cryptographic payload at the front of each video chunk that is demultiplexed. By utilizing a reserved start code, the decrypt engine **26** can pass the entire video data including the inserted cryptographic material to the decoder **20** that simply discards or ignores the cryptographic material. For example, a MPEG-4 compliant decoder discards frames that contain a

reserved start code identifier that is included in the bitstream. Accordingly, removal of any of the cryptographic material from the bitstream is not needed to decode the associated data.

The cryptographic payload in one embodiment includes three different packet types: a wrap key, a synchronization payload and a frame payload. The frame payload indicates that the current frame is encrypted and includes key information and a reference to at least a portion of the encoded frame that is encrypted. The frame payload can be used to decrypt the video frame. The synchronization payload is the first packet sent to synchronize the authentication engine of the demultiplexer to the decrypt engine of the decoder. This synchronization ensures that data transmitted from the demultiplexer to the decoder is not being intercepted. The wrap key includes information to unwrap or decipher the transmitted data from the demultiplexer.

The bit stream inserter **17** packages the cryptographic material for transport with the video data. Conversely, the bit stream decoder **27** of the decoder unpacks the cryptographic material from the bitstream. In one embodiment, frame keys are transported in the bitstream and are sent when a key index change is detected by the authentication engine of the demultiplexer. In many embodiments, the decrypt engine of the decoder stores only one frame key and thus frame encryption information sent by the demultiplexer applies to the current frame. If the decrypt engine receives a new frame key from the demultiplexer, the decrypt engine stores the new frame key and uses it to decrypt the next frame. In a number of embodiments, a key table is transmitted and stored in the decrypt engine for reference by subsequent encryption information. In several embodiments, the decoder does not enforce key rotation. In many embodiments, however, the decoder expects a new frame key after a predetermined number of frames in the sequence of frames. In this way, the decrypt engine can identify when supplied frame information is unreliable and terminate the decoding of the multimedia bitstream.

The wrap key factory **19** encrypts or wraps the cryptographic material for transport on the bitstream to the decoder. In one embodiment, the wrap key factory uses a key wrap process based on the Advanced Encryption Standard (AES) and uses the ECB Cipher Mode to provide cryptographic security for wrapping small blocks of data using chaining and cipher feedback loop. The key wrap process is stateless. A corresponding wrap key factory is included with the decoder to unwrap the cryptographic material. Synchronization with the corresponding wrap key factory **29** is used to allow unwrapping of the material without communication back to the demultiplexer (i.e., bi-directional communication) and to prevent unauthorized decoding of the content by, for example, a rogue process intercepting or copying the transmitted content.

Wrap Key Factory

In one embodiment, each of the authentication and decryption blocks (digital rights managers **15**, **25**) construct a series of predictable transform number sequences using a common heuristic. Subsequently, those numbers are combined with a random value for additional entropy used to contribute toward key material for wrapping keys.

A flow diagram of a wrap key generation process **300** in accordance with an embodiment of the invention is illustrated in FIG. **7**. A selected heuristic (**302**) is combined with key material (**304**) to create a wrap key (**306**).

In accordance with various embodiments, one such heuristic (**302**) may combine the use of a predictable number sequence generator such that identical transform sequences

US 10,484,749 B2

9   10

can be generated by different heuristics even though no information is exchanged. If both authentication and decrypt blocks are created such that the output of the common heuristic are identical, the key material (**304**) generated from such heuristic will be identical. This may apply in situations where a wrapped key (**306**) and a selected heuristic (**302**) are provided. Any process for generating identical encryption keys without exchange of key material can be used as an appropriate heuristic to generate wrapping keys (**306**) in accordance with embodiments of the invention. Although, some information exchange to enable synchronization between the two wrap key factories can be utilized in accordance with embodiments of the invention.

The two wrap key factories use the same transform sequence. To synchronize the wrap key factories, the sender's wrap key factory selects one heuristic (**302**) from a predetermined set of heuristics to generate the key material for the next wrap key. The decoder factory will receive a known payload that has been encrypted with the sender's wrap key (**306**) generated using selected heuristic (**302**) from the known set of heuristics. The receiver then attempts to decrypt and verify the contents of the payload using each of the predetermined heuristics. If the material matches what is expected, then the receiver has identified the correct heuristic (**302**). If all the heuristics are exhausted, then this is considered a fatal error and decryption cannot continue.

Initially, the synchronization payload is used to assist the decrypt block in identifying the appropriate transform sequence quickly. Once the decrypt block locates the proper heuristic (**302**), the decrypt block wrap key factory utilizes that transform sequence for all subsequent transforms. In several embodiments, once a heuristic has exhausted all values, that heuristic will deterministically choose the next heuristic to use.

Run time synchronization is maintained through monotonically incrementing a wrap number that is incremented for each wrap key generated. If an error occurs using a particular wrap key (i.e. unallowable data present in the cryptographic payload), the wrap key factory will regenerate a new wrap key and subsequently increment the wrap number. In one embodiment, the frame payload received by the decrypt block contains a wrap number element. On the decrypt block, this wrap number element is compared with the internal wrap number of the decrypt block to determine if the current wrap key needs to be skipped. In one embodiment, the wrap key includes data fed into a cryptographic digest. The resulting bytes from the digest are then used to create an AES key. A new wrap key will be generated for each payload that is wrapped.

Bitstream Data Insertion

A flow diagram of a bitstream insertion process **400** utilized with respect to video data extracted from an AVI container in accordance with an embodiment of the invention is illustrated in FIG. **8**. In the demultiplexer, a caller begins extraction (**402**) of a relevant AVI chunk and requests (**404**) the DRM for the maximum expected bitstream payload. The demultiplexer then uses the information from the DRM to allocate (**406**) space in a buffer and passes (**408**) the buffer to the DRM. Next on the DRM, the video DD info is cached (**410**). The video DD info may be a data segment in a file container describing the data contained in a single block of container data, such as all of the video frame data in a single AVI chunk. Encrypted frames may have a DD info which contains information relating to the security features of the frame. The MPEG4 reserved start code is inserted (**412**) into the buffer and then the cryptographic payload header is inserted (**414**) into the buffer. A decision

(**416**) is then made as to whether the chunk is the first frame. If the chunk is the first frame, then a Sync( ) payload is inserted (**418**) and a FrameInfo( ) payload is inserted (**420**). The Sync( ) payload may include the wrap key synchronization payload to synchronize the wrap keys. The FrameInfo( ) payload may include the cryptographic offset and length of information relating to data security in the video data, possibly as part of the DD Info data. If the chunk is not the first frame, then only the FrameInfo( ) payload is inserted (**420**). Then, a decision (**422**) is made as to whether the key index is greater than the current key index. If the key index is greater than the current key index, a FrameKey( ) payload is inserted (**424**) in the buffer and then the number of bytes inserted into the buffer is returned (**426**) to the caller by the DRM. The FrameKey( ) payload may include the payload containing the next frame key. If the key index is not lower than the current key index, then the DRM returns (**426**) the number of bytes inserted in the buffer to the caller. Next, the demultiplexer, is ready to extract (**428**) the AVI chunk. Through this process, DD info awareness occurs before the demultiplexer extracts the video chunk into the buffer for transmission to the decoder.

In various embodiments, bitstream data insertion occurs in the authentication block of the demultiplexer. The digital rights manager in one embodiment first receives the container's encryption data and temporarily stores or caches the information. The cached encryption data contains the information for the next video chunk. From this information, the digital rights manager can determine the proper bitstream payload to insert, if any. To reduce memory copies, the digital rights manager inserts the bitstream payload before extracting the chunk from the container.

Based on the cached encryption data chunk, the digital rights manager can detect frame key changes. If the frame key index has not changed since the last cached encryption data, no key material is sent. In one embodiment, the encryption data is always transported if there is cached encryption data in the digital rights manager. On the first payload, there will be a synchronization payload to allow the decrypt block to synchronize the wrap sequence. The frame information payloads in one embodiment follow the synchronization payload. It should be appreciated that not all payloads are required to appear in each decrypt block. Furthermore, the processes similar to those described above with reference to FIG. **8** can also be used with respect to other container formats including but not limited to MKV container files.

Although the present invention has been described in certain specific aspects, many additional modifications and variations would be apparent to those skilled in the art. It is therefore to be understood that the present invention may be practiced otherwise than specifically described, including various changes in the size, shape and materials, without departing from the scope and spirit of the present invention. Thus, embodiments of the present invention should be considered in all respects as illustrative and not restrictive.

What is claimed is:

1. A playback device for playing back encrypted video, the playback device comprising:

a set of one or more processors; and

a non-volatile storage containing a playback application for causing the set of one or more processors to perform the steps of:

receiving a container file with video data at a parser;

extracting portions of the container file using the parser, wherein the container file comprises video data with a partially encrypted frame, cryptographic informa-

US 10,484,749 B2

11 12

tion, and a block reference that identifies a portion of the partially encrypted frame, and wherein the partially encrypted frame contains encrypted portions and unencrypted portions of data;

providing the partially encrypted frame, the cryptographic information, and the block reference from a demultiplexer to a video decoder;

deciphering, at the video decoder, a frame key by which the portion of the partially encrypted frame is encrypted using the cryptographic information and a key table stored on the video decoder;

identifying the encrypted portion of the partially encrypted frame using the block reference;

decrypting the encrypted portion of the partially encrypted frame using the frame key and the video decoder; and

decoding the decrypted portion of the frame for rendering on a display device using the video decoder.

2. The playback device of claim 1, wherein the partially encrypted frame is provided by the parser to a video decoder over an unsecured channel.

3. The playback device of claim 1, wherein the playback application is further for causing the set of processors to separately obtain the key table.

4. The playback device of claim 1, wherein the playback application is further for causing the set of processors to provide a second frame key index and a second block reference from the demultiplexer to the decoder.

5. The playback device of claim 4, wherein the playback application is further for causing the set of processors to:

identify a second encrypted portion of a second partially encrypted frame using the second block reference;

decrypt the second encrypted portion of the second partially encrypted frame using a second frame key identified by the second key index and the video decoder; and

decode the decrypted second portion of the second frame for rendering on the display device using the video decoder.

6. The playback device of claim 1, wherein the block reference comprises offset and length information.

7. The playback device of claim 1, wherein the cryptographic information comprises an encrypted frame key.

8. The playback device of claim 7, wherein the playback application is further for causing the set of processors to communicate with a digital rights management component to decipher the frame key.

9. The playback device of claim 1, wherein the key table is encrypted to enable playback by a particular user.

10. A method for playing back encrypted video, the method comprising:

receiving a container file with video data at a parser;

extracting portions of the container file using the parser, wherein the container file comprises video data with a partially encrypted frame, cryptographic information, and a block reference that identifies a portion of the partially encrypted frame, and wherein the partially encrypted frame contains encrypted portions and unencrypted portions of data;

providing the partially encrypted frame, the cryptographic information, and the block reference from a demultiplexer to a video decoder;

deciphering, at the video decoder, a frame key by which the portion of the partially encrypted frame is encrypted using the cryptographic information and a key table stored on the video decoder;

identifying the encrypted portion of the partially encrypted frame using the block reference;

decrypting the encrypted portion of the partially encrypted frame using the frame key and the video decoder; and

decoding the decrypted portion of the frame for rendering on a display device using the video decoder.

11. The method of claim 10, wherein the partially encrypted frame is provided by the parser to a video decoder over an unsecured channel.

12. The method of claim 10 further comprising obtaining the key table.

13. The method of claim 10 further comprising providing a second frame key index and a second block reference from the demultiplexer to the decoder.

14. The method of claim 13 further comprising:

identifying a second encrypted portion of a second partially encrypted frame using the second block reference;

decrypting the second encrypted portion of the second partially encrypted frame using a second frame key identified by the second key index and the video decoder; and

decoding the decrypted second portion of the second frame for rendering on the display device using the video decoder.

15. The method of claim 10, wherein the block reference comprises offset and length information.

16. The method of claim 10, wherein the cryptographic information comprises an encrypted frame key.

17. The method of claim 16 further comprising communicating with a digital rights management component to decipher the frame key.

18. The method of claim 10, wherein the key table is encrypted to enable playback by a particular user.

* * * * *